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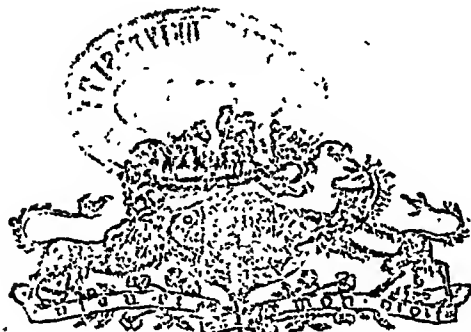
**SUTLEJ DAM PROJECT
1919.**

VOLUME

III.

LOWER SIRHIND CANAL

REPORT AND ESTIMATES.



Lahore :

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1921.**

SUTLEJ DAM PROJECT

LOWER SIRHIND CANAL.

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SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

REPORT.

CHAPTER I.

Fixing Site of Headworks and Alignment of Main Line.

1. Mr. Rose, Chief Engineer, when dealing with the Project in his note, dated 26th February 1916, assumed a Headworks below Phillour Bridge, which would give a command into the Abohar Branch at Daudhar, mile 43.

2. Contour surveys were carried out in what was known as the Phillour-Jagraon tract to enable the best alignment to be selected, it was however soon found that it was unnecessary to go up as high as Phillour Bridge to get command, and that it would not be desirable to construct a canal straight from that place to Daudhar as very deep digging would be involved to a great depth below spring level. Walipur 8 miles below Phillour was the next site considered, but here again similar though less pronounced conditions were found.

3. If the new canal cannot command above the Akhara Fall mile 31 of Abohar Branch, where the Jagraon Distributary takes off, nothing is gained in attempting to command above Rania, the Head of the Sutlej Navigation Channel, as between Akhara and Rania no irrigating channels take off which carry any material discharge.

To get command at Rania it was found unnecessary to put the Headworks nearly so far up the River as Phillour.

4. By the time the investigation for the site of the Headworks had reached this stage, it had been decided that it would be much better to set free more of the capacity of the existing Sirhind Canal Main Line by extending the new canal to feed the Bhatinda Branch. The consideration of this question led to the decision that the Abohar Branch should be commanded and fed by the new canal just below the Daudhar Fall at mile 43 of the Branch.

5. With this decision arrived at it only remained to find the best alignment for the Main Line up to the river from Daudhar and then locate the Headworks at a site which would give the required command into the canal.

This is a reversal of the usual practice where the Headworks site is fixed and the canal taken off therefrom to command what it can, and it involves the consideration of the Main Line alignment and the location of the Headworks site together.

6. By this time also the decision had been arrived at that the main channels were to be lined with concrete, this introduced a new factor into the question of alignment of the Main Line.

With a concrete lined channel it is undesirable to have the bed below spring level, as there would be the tendency for the water pressure to blow up the lining, and it would be impracticable on the score of expense to make it sufficiently heavy to resist any material head of water pressure.

This condition alone precluded the straightest alignment from being selected, apart from the fact that the depth of digging found on such an alignment would have been very much heavier than on the one selected.

7. The alignment was arrived at after mature consideration of tentative lines plotted from the contour surveys, followed by actual detailed planetable

surveys in the field, the water surface in the wells being levelled in the vicinity of the alignments.

8. The longitudinal section of the alignment finally selected (see plan in Folio) shows that the subsoil water levels in the wells at the time of survey were just below the proposed bed level in the reach of highest spring level. It may happen that the spring level will fall after the completion of the Sutlej Dam Project owing to the Abohar Branch being abandoned, or it may be that the slight percolation of two casecs allowed for a lined channel will locally increase the spring level. There does not, however, appear to be much chance of any great rise, as the river is not far distant at a much lower level and can thus act as a drain.

9. The effect of the Sirhind Canal in raising the spring level in the tract is shown in the two plans attached Nos. G. and H. which give the depth of spring level below natural surface in Ferozepore and Ludhiana Districts at the last settlement, and the rise in level since the previous one. These plans are interesting as they shew the mean depth to the water surface of the wells in each village and are the result of the average of a large number of wells. The earlier settlements of these two Districts took place before the canal was constructed or developed, and give data over the whole area from an earlier year than the canal well measurement cross lines which were only started in 1895 and do not extend over the tract.

10. The selected alignment of the Main Line came close to the river at Sidhwan, where the necessary command could not be obtained; it then only remained to continue the main line upstream at the proposed grade 1/8,000 until command was obtained from the river which has a slope of 1/3,000.

The question then arose as to what command was desired and to what extent it was permissible to head up the river by means of the weir, to gain the necessary command.

11. While the surveys were in progress, the writer was permitted to inspect all the Headworks of Canals in the Province which take-off from rivers in the alluvial plains of the Punjab.

The history of design and subsequent working of each Headworks was investigated from the original records and it was found that the chief difficulty with all the Headworks except Rupar, was want of command over the river, that is to say that the weir was not high enough to head up the river sufficiently for satisfactory regulation and silt control.

12. Attached are key diagrams showing the salient conditions of important levels in the design of the existing Headworks, it will be noticed from these how there has been a continual tendency to raise the existing weirs. At Rupar Headworks, the most satisfactory of all, the top of the shutters is now $7\frac{1}{2}$ feet above the original crest level of the weir, which in the first instance was designed of sufficient height to give what was then considered to be necessary for command into the canal.

13. The height of the top of the weir gates has therefore been fixed on these grounds, and partly on account of the fact that the higher the pond level above the weir, the shorter the length of the Main Line required to get the necessary command out of the river, a great consideration when an expensive lined canal is to be constructed. Furthermore it enables the canal bed to be kept at a high level in the river lowlands, thus avoiding trouble from spring level.

With the site finally selected for the Headworks the depth of digging is only 5 feet in the head reach of the canal.

14. Reference may be made to the river survey map below Phillour, scale 4" to 1 mile (in Folio of Plans) which is based on the stones of the riverain boundary survey by the Survey Department of the Government of India. From this map it will be seen that the canal alignment comes out of the high land into the river low lands near Gorsian, and if the command obtainable from the river at this point had been sufficient, it would have made an excellent site for the Headworks but unfortunately it was not without having what according to present practice is deemed to be too high a weir.

For the last 80 years at least the river for a distance of about 2 miles in the vicinity of the weir has flowed in one channel which hugs the high promontory consisting of hard clay containing kankar on which Gug and Burj Hassan villages are situated.

15. Gauges were maintained at Sanghowal, Burj Hassan and Gorsian for two seasons and these with a survey of the water surface in a high river and local information regarding floods together with the records at Phillour, Rupar and Bhakra gave sufficient details regarding the probable levels that would be likely to occur downstream of the weir at any site which might be selected.

16. Cross sections of the river were taken on each of the lines joining the base stones of the riverain survey. The result of all this information and surveys is recorded on the sections (in Folio of Plans Headworks).

17. Correlating with Rupar, what may be considered to be the normal hot weather river level was determined. From this the level of the top of the shutters or gates was obtained which would give the same amount of command over the river as at Rupar.

With the top level of the gates thus fixed with reference to river water surface levels, and allowing a two feet difference between that and canal full supply, the position of the weir site fixes itself, and is shown on the map in the village lands of Bhundri near the obelisk commemorating the Battle of the First Sikh War known to historians as the Battle of Aliwal. From this battle-field the Headworks will take their name.

18. The Headworks were designed first as an ordinary 6 feet shutter weir with undersluices on both flanks. The result was not however satisfactory, and the proposal to have the arrangement as now shewn was approved by the Chief Engineer (Mr. Holms).

Under sluices to consist of 8 bays 30 feet span 18 feet high gate.

Weir to consist of 28 Bays 60 feet span 10 feet high gate.

19. As a result of careful investigations made in 1917 the maximum flood discharge of the Sutlej at Rupar has been fixed by Chief Engineer in his No. 0953-W. I., dated 17th August 1917, at 260,000 cusecs.

The Headworks at Aliwal of the Lower Sirhind Canal are 55 miles below

I doubt if this has been correctly taken.
What about the drainage which comes
into the river between Rupar and Aliwal.

H. W. M. IVES,
Chief Engineer.

12th June 1919

works at this site need be designed.

Rupar, while the maximum discharge of the flood at Rupar is that of a very sharp peak, the absorptive capacity of the river channel and lowlands in that length is considerable, so the Chief Engineer accepted 200,000 cusecs as the maximum flood discharge for which the Head-

CHAPTER II.

Description of Alignments. MAIN LINE UPPER.

1. The new main channels of this canal are to be lined throughout with concrete giving a value of "N" in Kutter's formula of '015.

2. The Main Line takes off on the skew with an obliquity of 1 in 3. The face of the regulator itself is skewed from the axis of the river at 1 in 4. The Regulator is suitably designed accordingly.

This has the advantage of avoiding the long sweeping curve that occurs in the head reach of all the existing Punjab Canals, increasing the length, which in this case with a concrete lined channel would be very costly.

The conditions at this site are peculiar in that if the customary curve were adopted, the canal alignment would strike into deep digging much sooner than would otherwise be the case.

3. The alignment runs in the river lowlands in shallow digging and crosses the Budha Nala, which is passed under the canal at mile 2.2 in a culvert of three barrels 8-feet diameter. This Nala (see Chapter III, paras. 42 and 43) is diverted into the river upstream of the left bank marginal bund. The water which the syphon will have to carry, will only be that collected from the catchment area left inside the marginal bund, plus the drainage off the uplands entering it.

It is estimated that at Ludhiana 44 miles from Chamkour where the Budha Nala catchment starts, the maximum discharge is 3,000 cusecs giving 69 cusecs as the rate of run-off per mile of Nala. From the upstream bund where the Nala is diverted into the river to the canal crossing the distance is 9 miles, which at the same rate of flow-off would give about 600 cusecs as the probable maximum discharge to be passed under the canal.

4. The canal enters high ground at mile 3.9 and continues between the two village sites of Bhaini and Bhamal until at the Sidhwan-Jagraon pacea road, the Main Line Upper ends.

Grey Canals Feeder.

5. The Grey Canals Feeder taking off to the right from the tail of the Main Line Upper is an earthen channel. Bed width 56 feet, slope 1 in 5,000, which gives the required discharge of 1,000 cusecs with a full supply depth of 6.2 feet.

6. The Grey Canals are very inefficient and the Feeder is designed to run with a depth of 6.2 feet giving a normal supply of 1,000 cusecs, which can be raised to 8 feet and 1,600 cusecs to ensure that there will be no difficulty in maintaining the irrigation on these inefficient canals, which will remain unaltered. The Feeder will only link up the heads of the existing canals above Ferozepore and give them an *assured* supply from the Lower Sirhind Canal.

It is unnecessary to go further into the question of the desirability of improving these canals here as the matter is dealt with in Chapter VI.

7. The Feeder runs in a new channel for 3 miles till it meets the Kingwah Canal at mile 3½, from which point the Kingwah is remodelled for 4 miles to carry the increased supply required up to mile 7 of the Feeder. The Feeder then leaves the Kingwah alignment and at mile 10 meets the Aghawah Canal at minus mile 4,* from which point the Aghawah is remodelled for 2½ miles to carry the increased supply up to mile 12½ of the Feeder. The Feeder leaving the Aghawah runs for a mile in a new channel to meet the Bacherewah Canal at minus mile 10. The Bacherewah is then remodelled for 10 miles to the head regulator to carry the increased supply up to mile 23 of the Feeder.

*NOTE.—As the heads of the inundation canals are liable to shift the reduced distances commence from a point some way down the channel, from this point up to the river the reduced distances are reckoned negative.

The Feeder then leaves the Bacherewah and at mile 26½ meets the Barneswah at minus mile 5. The Barneswah is then remodelled for 9 miles to the head regulator of the Mayawah where the new Feeder ends at mile 36.

MAIN LINE LOWER.

8. The Main Line Lower is that reach of the Main Line below the regulator at the tail of the Main Line Upper on the Sidhwan-Jagraon road where the Gray Canals Feeder takes off. The reduced distances are continuous for the two portions beginning at the head regulator in the river.

The Main Line Lower should have its zero at its head.

H. W. M. IVES,
Dated 13th June 1919. Chief Engineer.

Below the road the canal runs along a carefully selected alignment determined as described in Chapter I.

This lined channel has a bed width of 163 feet, full supply depth 10 feet, and bed slope 1 in 8,000 giving the required discharge of 8,240 cusecs.

Spring level is only just a little below the level of the bed up to mile 14, beyond this point the subsoil water surface falls away.

9. It is worth while considering here what might be done if spring level rose so as to cause trouble to the lining during canal closures.

With the canal bed slope of 1 in 8,000 from the head of the main line to the regulator at mile 8·8* the difference of level is 5½ feet; by putting down the gates in this regulator when the canal is closed, a depth of from 10 feet to 5 feet could be maintained on the lining which would prevent any trouble from uplift due to any possible rise in spring level in the vicinity.

*End of Main Line Upper and head of Main Line Lower.

H. W. M. IVES,
Dated 13th June 1919. Chief Engineer.

It would be a wise precaution to make, say, the district road bridge at mile 17·2 similar to the regulating bridge at the Sidhwan-Jagraon road but without the gates, so that it would be easy hereafter to put in gates, if it was found desirable to hold up water on the bed of the canal, to counteract a rise in spring level.

10. At R. D. 19·3 miles the Grand Trunk Road Ludhiana to Ferozepore and at R. D. 19·7 miles the Ferozepore-Ludhiana Railway will be crossed, the latter a little less than a mile outside the distant signal of Ajitwal Railway Station where the Canal Railway will take off.

11. At mile 21·3 the Jagraon Distributary will be crossed just above the fall at which the Buttar Branch takes off, the distributary being passed over the Main Line in a masonry aqueduct on the top of which a road will run.

At mile 24·5 the Daudhar Branch of the Jagraon Distributary will be crossed; this branch is carried across the piers of the bridge prolonged, in a 3-foot diameter steel tube.

12. The alignment does not intersect any cross drainages that carry appreciable discharge, except the one near Daudhar village, mile 26½, which runs in years of heavy rainfall and for which a drainage inlet is provided. Three other inlets are provided to deal with local drainages indicated by the contours.

13. The Main Line finally ends at mile 27·6 where it meets the Abohar Branch below the Dandhar Fall at mile 42·6. At the tail of the Main Line the channel bifurcates, the Abohar Branch Regulator being on the right side and the Regulator for the Abohar-Bhatinda Feeder being practically normal to the tail of the Main Line. The full supply level at the tail of the Main Line is maintained the same as the existing full supply level in the Abohar Branch. The changes in level of bed and full supply in the Abohar Branch are described in connection with that channel.

ABOHAR BRANCH ALTERATIONS.

14. The Lower Sirhind Canal Main Line will meet the Abohar Branch below the Daudhar Fall. The full supply level in the Main Line being maintained at that of the existing Abohar Branch. The longitudinal section of the reach of the Abohar Branch affected is given in prolongation of the longitudinal section of the Main Line in the Folio of Plans.

15. It is undesirable to have the full supply level downstream of a regulator the same as that upstream. A fall of 1 foot is allowed, so that during rotational working objectionable heading up in the main channel is lessened. At the same time it makes it possible for the discharge of the branch to be increased by simply increasing the depth of supply should it at any date become desirable.

16. The existing full supply discharge of the Abohar Branch below Daudhar is 2,396 cusecs which will become 3,074 cusecs in the Kharif owing to extensions in Faridkot State, Ferozepur and in Muktsar Hithar.

17. It is considered desirable to have the bed of the Abohar Branch flush with that of the tail of the Main Line, allowing a full of water surface of 1 foot through the Regulator, this gives a full supply depth of 9 feet.

18. The existing bed slope of the Abohar Branch can with advantage be flattened from 1 in 6,250 to 1 in 6,666 down to the Gholia Fall at mile 51.

The bed level of the Abohar Branch will therefore be lowered about 2 feet at the head and 1.5 feet at the tail while the full supply depth will be increased to 9 feet which will maintain sufficient command into the Sutlej Navigation Channel and the Baga and Raota Distributaries.

19. If the channel is maintained unlined the bed will have to be widened from 80 feet to 100 feet as far as the head of the Sutlej Navigation Channel and the work has been estimated for accordingly.

Spring level is high in this tract and it is possible that by time the Project comes to be put in hand this reach from Daudhar to Gholia will be lined as a charge to the existing Sirhind Canal capital account; the lining of the channel will give the increased discharge required without further alteration.

This is very improbable as canal closures are few and far between.
18th June 1919. H. W. M. IVES,
Chief Engineer.

THE ABOHAR-BHATINDA FEEDER.

20. This lined channel graded 1 in 6,666 has a bed width of 112 feet and full supply depth of 9 feet giving the required discharge of 5,130 cusecs.

21. The Wadui Distributary alignment is crossed just a little below the Head Regulator, it is dealt with by shifting its alignment up to the head and carrying it across in a steel trough aqueduct on the piers of the Regulator lengthened downstream.

The capacity of the distributary will be increased to 60 cusecs to maintain the existing Wadni Distributary irrigation, and supply a new branch distributary which will run along the right bank spoil of the Feeder to supply the tails of the Manoki and Raikot Distributaries, which will be cut off by the Feeder and for which no crossings need then be provided.

22. Several alignments for the Feeder were investigated and laid out on the ground, the one finally selected is the straightest and only deflects slightly to the left for the first three miles to keep the channel in deeper digging across the Lapon Drainage. This drainage is the largest crossed in the tract and is taken into the canal by an inlet.

Two other drainage lines are crossed at miles 6 and 14, but there are neither records of nor signs of any flow. Provision has, however, been made for drainage inlets.

23. The Alkara Minor near mile 15 although shown on the map as existing has been abandoned so no crossing is provided.

24. The alignments of the Bhadaur and Dhipali Distributaries and the Ghanda Banna Minor have to be crossed and the channels will be carried across the Feeder in steel trough aqueducts on the piers of road bridges which are provided at the sites of the crossings. Slight modifications will be required in the distributary levels as described in the estimate under G. I.—Canal Crossings and Appendix B. 9.

25. The Feeder ends at mile 25 where it meets the Bhatinda Branch upstream of Dhipali Bungalow near mile 58½.

At the tail the channel bifurcates, the Bhatinda Branch regulator being on the right and the regulator for the Phul Feeder being practically normal to the tail of the Feeder.

26. The full supply level at the tail of the Abohar-Bhatinda Feeder is maintained the same as the existing full supply level in the Bhatinda Branch.

The changes in level of bed and full supply in the Bhatinda Branch are described in connection with that channel.

ALTERATIONS TO THE BHATINDA BRANCH.

27. The Abohar-Bhatinda Feeder meets the Bhatinda Branch near Dhipali Bungalow, the full supply level in the Feeder being maintained at that of the existing Bhatinda Branch.

The longitudinal section of the reach of the Bhatinda Branch affected is given in prolongation of the longitudinal section of the Abohar-Bhatinda Feeder in the Folio of Plans.

28. The bed level of the Bhatinda Branch will be brought down 3.3 feet to be flush with the tail of the Feeder. The bed slope to Sadhana Fall will be flattened from 1 in 6,250 to 1 in 6,666. This will mean a lowering of the bed above the fall by 3.1 feet.

29. The loss of command at this fall will be immaterial since the Mari Distributary, which at present has a poor working head, will be linked on to a new distributary supplied from above the Balloki Fall; this is described in connection with the alignment of the Phul Feeder.

30. The increase in full supply required for the Bhatinda Branch under the Project will only be 134 cusecs, necessitating no material alteration in the section of the channel which will remain unlined.

PHUL FEEDER.

31. This lined channel graded 1 in 6,666 has a bed width of 85 feet and full supply depth of 9 feet giving the required discharge of 3,896 cusecs.

The alignment for the channel finally selected is straight for its 6 miles length up to its tail where it crosses the curve in the Rajpura-Bhatinda Railway line about 2 miles east of Rampura-Phul Railway station.

32. At the tail of the Phul Feeder, the Bhatinda-Bikaner, the Rori (A-9) Feeders and the new low level Phul Distributary are taken off.

33. The existing irrigation on the right bank of the Feeder, cut off by it, will be maintained by constructing a new distributary from above the Balloki Fall, parallel to the existing Bhatinda Branch as far as to the head of the Phul Feeder, where it will be taken across in a steel aqueduct on the piers of the Head Regulator.

A small minor will be run along the right bank of the Phul Feeder to supply the tails of the present Raya and Chotia Minors.

The new distributary will be continued along the Bhatinda Branch to take up the irrigation of the Mari Distributary with a better command than that now obtained from the Bhatinda Branch.

34. The Phul Distributary will be crossed by the Feeder just before mile 6 of the latter and will be carried over it in a steel aqueduct on the piers of a Road Bridge.

As the alterations of the Phul Distributary are very complicated and are affected by several channels, the whole question will be dealt with now to save unnecessary repetition in connection with the various channels.

35. A new low level Phul Distributary with a capacity of 120 cusecs will be taken off the tail of the Phul Feeder between the head regulators of the Bikaner and Rori (A-9) Feeder.

This new distributary will be parallel to the Bhatinda-Bikaner Feeder and take up the irrigation below the 3 ft. fall at R. D. 72,280 of the existing Phul Distributary.

36. The irrigation left between the Bhatinda-Bikaner Feeder and the Phul Feeder will be done by the existing Phul Distributary, which will be carried across the Phul Feeder in an aqueduct.

In order to make this crossing possible the bed and full supply level of the existing Phul Distributary require to be raised, this is arranged for by eliminating two small falls which exist within a reasonable distance upstream.

37. The irrigation which will be cut off by the Bhatinda-Bikaner Feeder above the fall on the existing Phul Distributary and not supplied by the new low level Phul Distributary, together with the irrigation from the Bhundar Minor which will be cut-off by the Rori (A-9) Feeder, will be maintained by the following arrangement. As shown above the full supply level of the Phul Distributary just above the crossing of the Phul Feeder will be raised, thus making it possible for a new Minor from the existing Phul Distributary to be carried across the piers of the Rori (A-9) head regulator to supply the two new small minors which will be constructed parallel to the Feeders from their bifurcation.

This complicated re-adjustment of existing irrigation channels is shown in the Portfolio of Plans of the Lower Sirhind Canal, Phul Feeder Section.

THE RORI (A-9) FEEDER.

38. This lined channel graded 1 in 6,666 has a bed width of 38 feet and full supply depth of 8 feet giving the required discharge of 1,462 cusecs at the head. At mile 29.2 of the Feeder the Chautala Distributary takes off and the section lessens remaining a lined channel up to the tail, mile 34.4, with a bed width of 25 feet and full supply depth of 7 feet, giving the discharge of 813 cusecs required for the Rania and Bura Gudah Distributaries.

39. The alignment of such a Feeder for irrigating the tract was first investigated in 1905 and several subsequent alternatives were proposed. That now selected while being the most favourable for constructing a lined channel, at the same time gives the best command in the tract to be irrigated, and interferes least with the established irrigation *en route*.

40. Detailed planetable surveys were made to determine the best alignment and several were actually laid out and levelled over. The alignment is taken as nearly straight as possible to the highest point of Suratia village in British Territory avoiding villages *en route*.

41. Several State Distributaries are crossed but they are passed over or under the canal as levels permit in aqueducts or syphons, care having been taken to see that the efficient working of these channels, which belong to the Phulkian States, will not be interfered with. Details of the crossings of all these distributaries is given in Appendix B 9.

42. The alignment at mile 16 crosses the Southern Punjab Railway from Bhatinda to Delhi about a mile east of Maur Station from where the Canal Railway will take off for the carriage of the materials required for lining the channel.

43. The Kotla Branch will be crossed a mile below the Railway and a suitable syphon to pass the Kotla Branch under the Feeder has been designed.

The level of full supply in the Feeder obtainable here is not sufficient to command into the Kotla Branch at this point.

44. There are no drainages to be provided for on this channel.

THE BHATINDA-BIKANER FEEDER.

45. The alignment of this channel was selected to interfere as little as possible with existing irrigation, this keeps it alongside the Railway lines which water-courses do not usually cross; such an alignment has the further advantage of economy in carriage of materials during construction.

46. It has also been found possible to have few falls with substantial drops situated near Railway stations or Railway crossings which may eventually be useful in providing water-power for the economic development of the tract.

47. After investigating possible alignments on the contour maps the best was laid out and a planetable survey made by which that finally approved was fixed.

48. From the head to mile six the channel is taken parallel to the Rajpura-Bhatinda Railway and an 8 feet fall is obtained close to the Lahra-Mohabbat station. From this point the line could continue close to the Railway but to avoid any difficulty in getting between Lahra-Khana village and the Railway the alignment was shifted outside the village and kept parallel to the Railway as far as Buchchu station. From this point the channel alignment is fixed by the contours and the desire to get another fall of 9 feet at the crossing of the R. M. Railway, Bhatinda to Sirsa, at mile 22½. A small fall of 2.5 feet has been allowed at mile 15, but at the time of construction it may be found desirable to eliminate this small fall, by increasing the other two larger falls an equivalent amount, or by steepening the grade of the channel in the reach between the two falls.

49. A mile after leaving the R. M. R. Railway the Feeder crosses the Mehta Branch of the Bhatinda Distributary for which an aqueduct crossing has been provided on the piers of a road bridge.

It may be that when the work is taken in hand it will be found preferable to link the Mehta Branch on to the Tungwali Branch of the Phul Distributary.

50. At mile 27 the Feeder meets the Jodhpur-Bikaner Railway from Bhatinda to Hanumangarh and runs alongside of it up to mile 34 where it skirts an old drainage and then carries on to the tail at R. D. mile 46, less than a mile away from the Railway.

The alignment of this latter portion was one of the most difficult to determine in the whole project and many alternatives were surveyed. There are no drainages to be crossed on the alignment.

51. The channel will be concrete lined from head to tail graded 1 in 5,000 with a bed width of 52 feet and full supply depth of 8 feet which gives the required head discharge of 2,307 cusecs.

At the tail the channel bifurcates into the Bikaner Main Branch and the Bikaner Border Branch.

The whole cost of this channel as proposed will be borne by Bikaner State.

52. There will be a considerable fall into the Bikaner Border Branch which would be valuable to develop power for use in Dabwali, an important Mandi, on the Railway only two miles away from the site.

53. It would be advisable to reserve to the British Government the right to take-off a supply from the Feeder hereafter. For instance it might be found desirable to take out a small minor from the tail of the Feeder to irrigate the small area of British Territory between the two State Branches in preference to taking the requisite supply from the tails of the British Distributaries under the branches in syphons.

This is undoubtedly the correct scheme.
H. W. M IVES,
13th June 1919. Chief Engineer.

THE BIKANER BRANCHES.

54. **The Border Branch** from the tail of the Feeder is taken direct to the northern corner of Bikaner State. Detailed surveys were made in the field which led to this alignment being fixed.

This lined channel graded 1 in 5,000 has a bed width of 18 feet and full supply depth of 6 feet giving the required discharge of 518 cusecs at the head.

As soon as the Bikaner Border is reached at R. D. 44,000 the Branch ends and bifurcates into two distributaries. The area to be irrigated by these distributaries and supplied by this Branch has been determined on the 1 inch to 1 mile contour surveys by Mr. Glass; the limits of irrigation being fixed by the main drainage line and the limits of irrigation in Mr. Gibb's Sutlej Valley Project of 1917.

55. This project is prepared on the assumption that all new main canals and branches of the Lower Sirhind Canal will be concrete lined. The channels for Bikaner State will therefore have to be lined up to the State Border; it will be left to the discretion of the State whether the branches within the State boundary are lined or not. The project is based on the assumption that they will be lined and the estimates are prepared accordingly.

56. **The Bikaner Main Branch** from the tail of the Feeder is aligned alongside the Jodhpur-Bikaner Railway for 53 miles past Hanumangarh to near Lakhuwali Railway station, where it will bifurcate into tail distributaries. The alignment is one particularly favourable for lining as the Railway will deliver the materials required at site. The estimate has been prepared accordingly.

The lined channel, at the head graded 1 in 5,000, has a bed width of 36 feet, full supply depth 8 feet, which gives the required discharge of 1,638 cusecs.

57. The area to be irrigated is determined by the limits of irrigation of the Border Branch and Mr. Gibb's Sutlej Valley Project on the north and west, on the south the limit is fixed by the sand hills shown on the map and on the east the boundary is the left bank of the Ghaggar. The whole area of the Ghaggar bed below Suratgarh to the Bahawalpur State boundary is included also.

58. The details of the channel, the section of which is continually changing as distributaries are taken off *en route*, will be found on the longitudinal section in the Folio of Plans and in the Statement of Masonry Works, Appendix A 7.

Only one important fall occurs on the channel near Hanumangarh at which there is a difference of water surface level of 9'5 feet.

There will be a demand for the power which can be developed here for the Palace and the town which will in all probability expand rapidly when irrigation is introduced.

CHAPTER III.

Description of Aliwal Headworks.

SITE OF HEADWORKS.

1. The site is fixed about $12\frac{1}{2}$ miles below Phillour, after complete consideration of the command required in the Main Line at its junction with the Abohar Branch and in the Abohar-Bhatinda Feeder at its junction with the Bhatinda Branch, as previously described in Chapter I.

HEAD REGULATOR.

2. The bed level at canal head brought up from Daudhar with a bed slope of 1 in 8,000, which it is not deemed desirable to flatten, works out to R.L. 749.5.

The designed section of the canal for a kharif supply of 9,242 cusecs is, bed width 184 feet, depth 10 feet giving a critical velocity of 1.3 Vo., the canal being concrete-lined with a value of $N = .015$ accepted. Under these conditions in the Main Line there is not likely to be any silt trouble.

3. At Rupar in the existing Sirhind Canal Main Line, an earthen channel with a bed slope of 1/8,000, the silt difficulty has been solved by modification in design of the Headworks and scientific methods of regulation based on theory and experience.

4. In the design of the Aliwal Headworks as now submitted, further improvements are suggested based on experience at Rupar and on an investigation into the design and working of the other Headworks of the Province, as regards their efficiency in excluding the heavy or troublesome silt from the canal.

The top of the undersluice gates is fixed at R. L. 761.5 two feet above canal full supply. This gives ample working head for the regulator with a margin to allow for running an increased supply in the Main Line.

5. The regulator with a required full supply of 9,460 cusecs is designed with 16 Bays of 20 feet giving a discharge of 29 cusecs per foot run. A raised masonry crest at R. L. 754 will be needed, that is $4\frac{1}{2}$ feet above canal bed, or 10.5 feet above the pocket floor R. L. 743.5.

6. The formula for discharge through the regulator used is—

Unsubmerged portion $V a = c \times 2/3 \sqrt{2 g h}$

Submerged portion $V b = c \times \sqrt{2 g h}$

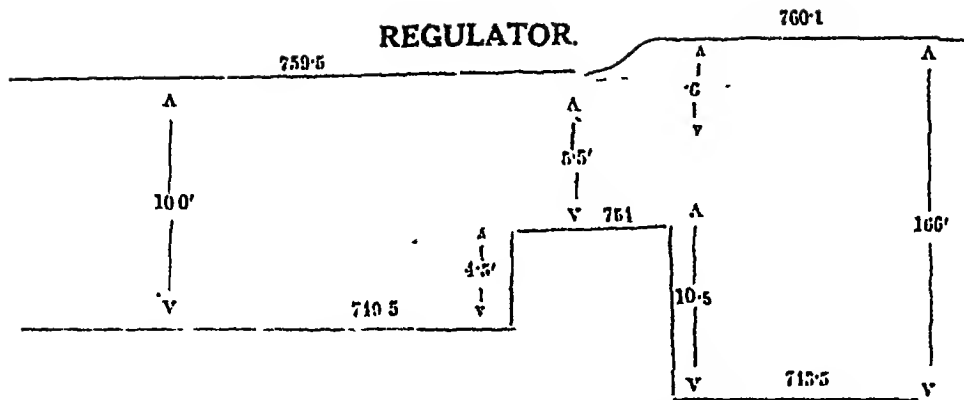
c and c_1 being assumed to be the same as deduced from the Rupa Regulator.

The co-efficient of Rupar Regulator when running full supply has been worked out from eight observations and found to be .82 assuming no velocity of approach. At the Aliwal Headworks with a skew regulator oblique to the axis of the river, instead of a normal regulator parallel to it as in the case of Rupar, the velocity of approach would increase the discharging capacity. No credit is taken, however, of this improvement and the dimensions of the regulator are fixed on the assumption of a co-efficient of .82 and no velocity of approach.

7. The head required to pass the full supply of 9,460 cusecs into the canal based on the above data works out to 6 feet thus:—

Lineal waterway 16 spans of 20 feet = 320 feet.

Discharge required 9,260 cusecs i. e., 29 cusecs per foot run.



Unsubmerged portion.

$$V a = c \times 2/3 \sqrt{2 g h}$$

$$= .82 \times 5.35 \sqrt{6}$$

$$= 3.38$$

$$D a = 3.38 \times .6$$

$$= 2.0$$

Submerged portion.

$$V b = c \sqrt{2 g h}$$

$$= .82 \times 8.025 \sqrt{6}$$

$$= 5.06$$

$$11 b = 5.06 \times 5.5$$

$$= 27.8$$

Total discharge per foot run = 29.8 cusecs.

8. It has been calculated that if a gauge of 11 feet were run in the canal, the discharge would be 10,640 cusecs and to force this through the regulator a head of .5 feet would be required, this would still leave a 6-inch free board to the top of the undersluice gates.

9. The mean velocity in the pocket normal to the face of the Head Regulator in the width of 400 feet and depth of water of 16.6 feet, when the canal is running full supply, would be $\frac{9,160}{400 \times 16.6} = 1.42$ feet per sec.

The value of V_0 for a depth of 16.6 feet is 5.1 feet per sec.

Hence the actual velocity is only $\frac{1.42}{5.1} = .28 V_0$ a very favourable condition to prevent heavy silt entering the canal.

The width between the upstream end of the regulator and the divide wall is 400 feet, the same as the length of the regulator. With the canal running full supply the discharge would be $\frac{9,160}{.40} = 23.8$, say 24 cusecs per foot run.

for $V = V_0$ the depth required would be ... 7.6 feet.

for $V = 1.3 V_0$, do. do. .. 6.5 feet.

The depth in the pocket at Full Supply is 16.6 hence $16.6 - 7.6 = 9$ feet of silt could deposit before sending water into the canal of V_0 standard.

Ample warning would thus be obtained of the necessity to scour the river approach to the head regulator through the pocket by the powerful sluicing conditions provided.

WEIR.

10. As already mentioned the maximum flood discharge to be passed has been fixed by the Chief Engineer at 2,00,000 cusecs.

The undersluices will have 8 spans of 30 feet the floor level being R. L. 743.5.

An unusual design for a weir

H. W. M. IVES.

Chief Engineer.

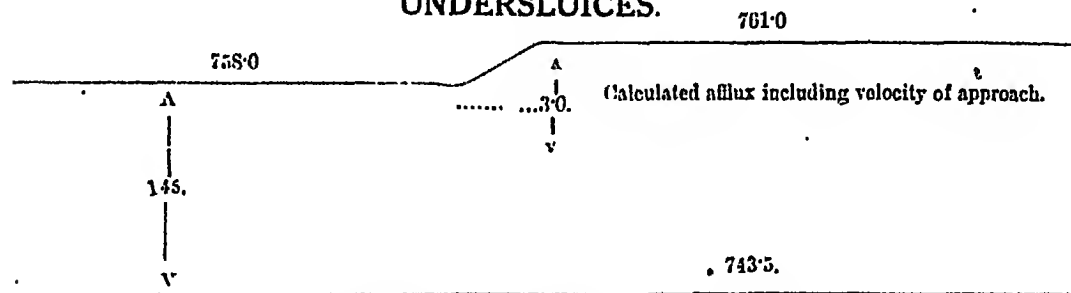
2nd September 1919.

The weir is designed with 28 bays of 50 feet with a crest level of 751.5. Details of the conditions of the river at site are shown in the Diagram of levels of Aliwal Weir. (Diagram B.)

A key plan of the Headworks is attached showing the general arrangement of Headworks. (Diagram A.)

11. The calculations below show that with the present recorded maximum flood level of R. L. 758 downstream of the weir, an afflux of 3 feet would be required to pass any maximum flood of 2,00,000 cusecs. This 3 feet calculated afflux neglects any velocity of approach, which would be equivalent to not less than 5 feet, giving an actual probable afflux of 2.5 feet, or 760.5 flood level upstream of the weir.

UNDERSLICES.



8 bays of 30 feet each i.e. 240 feet lineal waterway.

Unsubmerged portion.

Submerged portion.

$$V a = c \times \frac{2}{3} \sqrt{2 g h}$$

$$= 8 \times 5.35 \sqrt{3.0}$$

$$V b = c' \times \sqrt{2 g h}$$

$$= 8 \times 8.025 \sqrt{3.0}$$

$$= 4.28 \times 1.73$$

$$= 6.42 \times 1.73$$

$$= 7.4$$

$$= 11.1$$

$$D a = 7.4 \times 3$$

$$D b = 11.1 \times 14.5$$

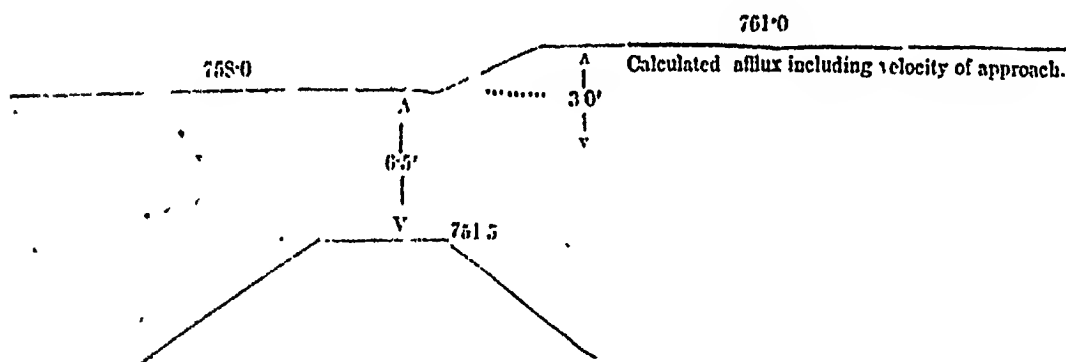
$$= 22.2 \text{ cusecs}$$

$$= 161.1 \text{ cusecs}$$

Discharge per foot run = $22.2 + 161.1 = 183.3$, say 183 cusecs.

Total discharge of undersluices $183 \times 240 = 43,920$ cusecs.

WEIR.



28 bays of 60 feet each, 1,680 feet lineal waterway.

$$V a = c \times \frac{2}{3} \sqrt{2 g h}$$

$$= 7.40$$

$$V b = c \times \sqrt{2 g h}$$

$$= 11.1$$

$$D a = 7.4 \times 3$$

$$D b = 11.1 \times 6.5$$

$$= 22.2 \text{ cusecs}$$

$$= 72.2 \text{ cusecs.}$$

Discharge per foot run $22.2 + 72.2 = 94.4$, say 94 cusecs.

Total discharge over weir = $94 \times 1,680 = 157,920$ cusecs.

Total discharge of weir and undersluices $43,920 + 157,920 = 201,840$ cusecs.

12. Below the other weirs of the Punjab Headworks it has been found that there is a tendency for the river bed to rise. This is due to the fact that in regulating the Headworks to exclude silt from the canal, the heavy silt is first deposited above the weir and at intervals of time this deposit is flushed out.

13. The mean discharge of the river is materially lessened by the amount of water drawn into the canal. Thus to carry on the deposited silt, a lessened volume of flow in the river has to carry an increased silt charge, which can only

be done by improving the hydraulic conditions favourable to increased silt transporting power. The river does this automatically by increasing its slope which causes a rise in bed and water surface below the weir.

14. At Rupar the rise is most marked, and it has been found that since the canal was opened the rise of the bed below the weir, is equal to the square root of the number of years that have elapsed since 1887 which agrees with the actual rise of 5 feet up to date.

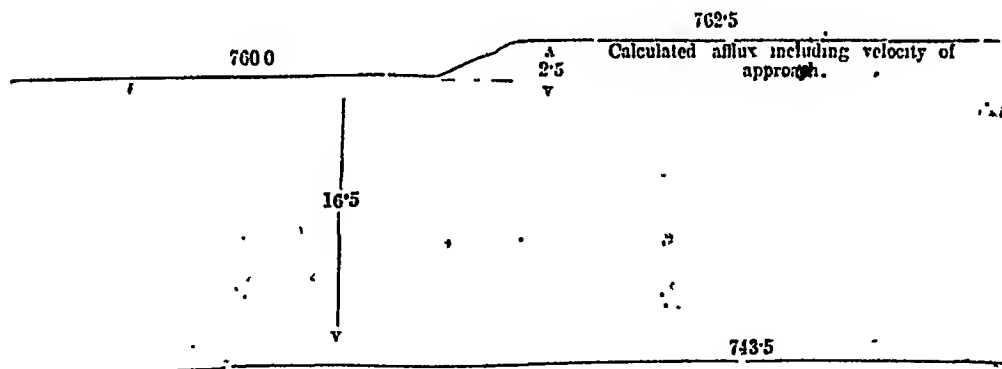
The rise in water surface in a high flood is not as much owing to the increase in surface slope.

At Rupar, however, the highest flood level was obtained downstream of the weir in 1913, although the flood was not by any means the greatest, in actual discharge or from the gauge four miles above the weir.

The fall in water surface over the Rupar weir was only 2.13 feet in the 1913 flood in place of 3.15 in the 1900 flood which was a bigger one. To provide for such future conditions developing at the Aliwal Headworks, it is presumed that a maximum flood level downstream of the weir of R. L. 760 may occur, that is 2 feet above R. L. 758 the maximum now recorded.

15. The calculations below show that with a presumed flood level of R. L. 760 downstream of the weir a calculated afflux of 2.5 feet would be required to pass the maximum flood of 200,000 cusecs; this 2.5 feet afflux calculated includes the velocity of approach which would be equivalent to not less than .5 ft. giving an actual afflux of 2 ft. or R. L. 762 flood level upstream of the weir.

UNDERSLUICES.



8 bays of 30 ft. each 240 feet lineal waterway
Unsubmerged portion.

$$V a = c \times \frac{2}{3} \sqrt{2 g h}$$

$$= .8 \times 5.35 \sqrt{2.5}$$

$$= 6.76$$

$$D a = 6.76 \times 2.5$$

$$= 16.9 \text{ cusecs}$$

$$\text{Discharge per ft. run} = 16.9 \times 167.3 = 184.2, \text{ say } 184 \text{ cusecs.}$$

$$\text{Total discharge of undersluices } 240 \times 184 = 44,160 \text{ cusecs.}$$

Submerged portion.

$$V b = c \times \sqrt{2 g h}$$

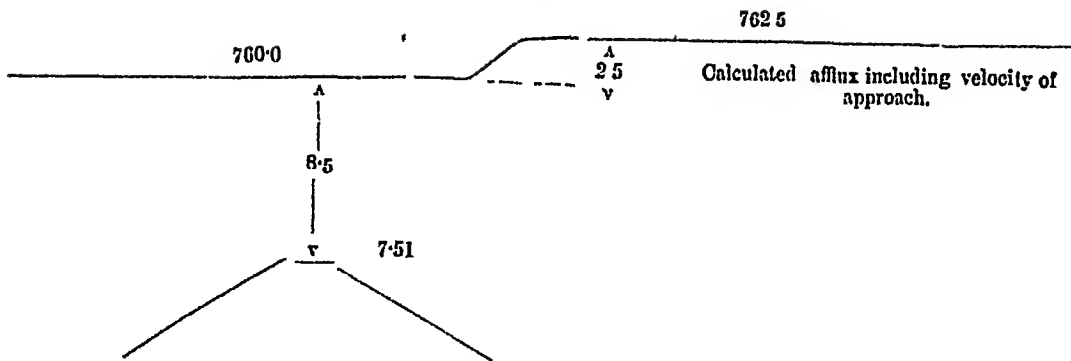
$$= .8 \times 8.025 \sqrt{2.5}$$

$$= 10.14$$

$$D b = 10.14 \times 16.5$$

$$= 167.3 \text{ cusecs}$$

WEIR.



28 bays of 60 ft. 1,680 Lft. waterway

Unsubmerged portion

$$V_a = c \times \frac{2}{3} \sqrt{2gh}$$

$$= 6.76$$

$$D_a = 6.75 \times 2.5$$

$$= 16.9 \text{ cusecs}$$

Submerged portion.

$$V_b = c \times \sqrt{2gh}$$

$$= 10.14$$

$$D_b = 10.14 \times 8.5$$

$$= 86.2 \text{ cusecs.}$$

Discharge per ft. run $16.9 + 86.2 = 103.1$, say 103 cusecs.

Discharge over weir $= 1,680 \times 103 = 173,040$ cusecs.

Total discharge of weir and undersluices.

$$44,160 + 173,040 = 217,200 \text{ cusecs}$$

16. The maximum depths of scour that might be expected under various conditions of flow can be estimated by the application of Kennedy's silt equilibrium theory, assuming the river to be Vo standard silt.

Narrowest distance between training works is 1,800 Lft.

In a maximum flood of 200,000 cusecs the discharge per foot run would be $\frac{200,000}{1,800} = 112$ cusecs, this would give a normal depth of 20 feet from water surface to bed.

This would cause a normal scour to $761.5 - 20 =$ R. L. 741.5 upstream of the weir, or $758 - 20 =$ R. L. 738 downstream of the weir.

The discharge calculated through the undersluice bays in a maximum flood $= 184$ cusecs per foot run but the wider waterway downstream of the piers would reduce the discharge to $184 \times \frac{30}{30+6} = 153$ cusecs per foot run.

This would give a normal depth of 21 feet from water surface to bed. Downstream of the Undersluices this would cause a normal scour to $758 - 24 = 734$ R. L.

If gates of the weir were opened with the pond level at R. L. 760 and the water surface downstream at the level of the weir crest, the worst condition for depth of scour would be obtained.

The discharge per ft. run would be—

$$V_a = c \times \frac{2}{3} \sqrt{2gh}$$

$$= .8 \times 5.35 \sqrt{8.5}$$

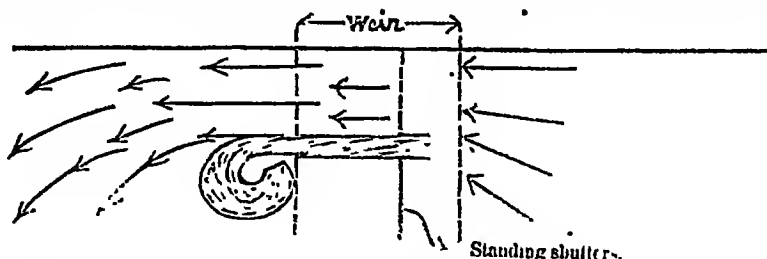
$$= 12.5$$

Discharge $= 12.5 \times 8.5 = 106$ cusecs this would give a normal depth of scour of 19.5 feet from water surface to bed, which with the downstream water surface at 751.5 would cause a scour to $751.5 - 19.5 = 732$ R. L.

17. An attempt has been made to calculate the maximum discharge which could be passed through the undersluices with the level upstream at R. L. 760 (normal pond level). The difficulty is to know exactly what the water surface level downstream of the undersluices would be, but if it is assumed that the water surface were 751.5, then the discharge passed would be about 60,000 cusecs or 210 cusecs per foot run which would give a normal scour depth of 30 feet, that is down to $751.5 - 30 = 721.5$ R. L.

This is the most acute condition that could be artificially caused and not likely to occur during actual working.

18. The damage to the talus downstream of a weir is nearly always due to the fact that the shutters have to be either up or down and the flow over the weir causes a severe swirling action downstream of the standing shutters, viz.:-



With a gated weir the discharge can be passed by partly lifting the gates of a whole bay of the weir so as to avoid the development of the destructive swirl on the talus.

This benefit has been most marked at Balloki Headworks where it is believed the talus of the weir has been very little displaced after the practice of lifting gates right across was instituted.

The damage from scour at the Aliwal Headworks will be much less on this account than is usual at other headworks.

DETAILS OF DESIGN.

19. It has been shown that eight undersluice bays of 30 feet span with floor level at 743.5 are required and 28 bays of 60 feet span on the weir with a crest level R. L. 751.5 or 8 feet above pocket floor.

The top of the gates has been fixed at R. L. 761.5 or 10 feet above the crest of the weir and 2 feet above full supply in the canal.

20. **Pocket.**—The regulator has been designed at a skew of 1 in 8 to the undersluices, the undersluices being skewed 1 in 8 to the weir, this gives a pocket with an entrance of a width equal to the length of the canal regulator, a condition favourable to stream line flow and the exclusion of silt as is mentioned above in connection with the design of the regulator.

21. The divide wall is designed of masonry, similar to that existing at Rupar, in preference to having a large earthen Bund pitched on both sides as at other Headworks which unnecessarily reduces the waterway of the weir. The nose of the divide wall will be founded on wells continued under the wall and stepped up until the normal open foundation depth is attained.

22. The whole pocket upstream of the undersluice floor and between the regulator floor and the divide wall, will be paved with 2 feet crane-lifted stone on 1 foot of ordinary stone and the surface grouted with concrete to be certain that the stones shall not be shifted under the high velocities generated in scouring the Pocket. Upstream of this paving and round the nose of the divide wall, a stout apron of concrete blocks will be laid as shown on the plan of the Pocket in the Folio of Plans; this should prevent the most acute swirl action undermining the Pocket floor.

A luxury that could as efficiently be replaced by 2' depth of selected angular stone hand-packed which would be much cheaper.

2nd September 1919. H. W. M. IVES,
Chief Engineer.

23. The divide wall is designed 700 feet long so as to be in line with the upstream wing wall of the regulator and mask the regulator more efficiently than the divide walls and bunds do at other Headworks, thereby ensuring more satisfactory scouring conditions in front of the regulator face.

The whole of the design of the Pocket and works in connection with it have been made strong in the first case, since it is very difficult and expensive to strengthen them afterwards as a total closure of the canal is entailed. If the officers in charge are nervous of utilising the sluices for scouring to their maximum capacity for fear of damage, the efficiency of the canal is materially lessened.

24. **Undersluices.**—The length of the undersluice floor is designed to give the requisite length of creep to prevent piping. The thickness of the floor

downstream is made sufficient to resist the upward pressure that will occur under the worst working conditions.

25. The piers of the undersluices have been made 6 feet thick and of sufficient length to carry the steel superstructure for the counterbalanced stoney gates and a Girder Road Bridge; this length will be sufficient for stability.

Not enough to accommodate the deep grooves required for Stony's gates.
H. W. M. IVES,
2nd September 1919. Chief Engineer.

26. The total height of gate required is 18 feet and this will be provided by having two gates in each bay working in the same groove as at Rupar. This arrangement for undersluices is the most satisfactory that has been evolved.

27. Beyond the undersluice floor the action caused by such powerful sluicing capacity calls for heavy protection, a 20 feet width of $4' \times 4' \times 2'$ concrete blocks on end over 2 feet of stone, followed by a 90 feet width, of 4 feet deep stone apron, is provided. It would be desirable to have all this stone, crane lifted stone, as at Rupar in place of the usual "one man" stone.

These blocks can be built in situ during construction.
H. W. M. IVES,
2nd September 1919. Chief Engineer.

28. **Weir.**—The total number of 60 feet spans is 28, of these the four on the right flank are skewed to the weir at 1 in 8 as in the case of the undersluices; this arrangement besides having the advantage of symmetry will cause the two deep channels which should form from the undersluices and the right flank of the weir, to meet between the two downstream spurs.

The water passing over the right flank of the weir will, therefore, be constrained to pick up the excess silt charge shot through the undersluices when scouring takes place, thus as far as possible mitigating the loss in efficiency of the undersluices which would otherwise occur.

29. The floor of the weir upstream has been given a reverse slope of 1 in 5 from the crest at R. L. 751.5 for a 40 feet width after that being made level for another 50 feet at R. L. 743.5.

This arrangement lessens the danger of the floor being undermined and increases its efficiency in preventing percolation and follows the precedent of Rupar and Merala rather than Khanki.

The floor ends in a small toe wall beyond which a 15 ft. stone apron 3 feet deep is provided.

30. It has been shown that the normal depth of flow in a 200,000 cusecs flood, on the Kennedy silt equilibrium theory would be only 20 feet or $1\frac{1}{2}$ feet below the surface of the upstream floor.

With no divide groynes upstream to cause the trouble experienced at Rasul and Khanki and with a gated weir it is improbable that there will be any displacement of this apron. The conditions are similar to those at Rupar where it has been found that there has been little or no action on the upstream apron in 35 years.

There are no divide groynes upstream of the Merala weir and therefore no trouble.
H. W. M. IVES,
2nd September 1919. Chief Engineer.

31. The foundations of weir crest and piers will be built on wells sunk to R. L. 730 to form an impervious cut off against percolation flow.

32. The weir glacis downstream has been given a slope of 1 in 10, this is a departure from the normal Punjab practice where 1 in 15 has been usual. At Rupar the slope has become 1 in 9 owing to alterations since construction.

The Jamna weir in Sind was constructed straight away with the steeper slope of 1 in 10.

The object of steepening the slope is to get the talus of a given length down to a lower level and into a position where it will be less liable to damage.

It all means extra pumping to get this in at a lower level.
H. W. M. IVES,
2nd September 1919. Chief Engineer.

33. The glacis is made impervious for a length of 65 feet downstream of the crest with a sufficient thickness to resist uplift, and ends over a shallow curtain wall $7\frac{1}{2}$ feet deep.

Beyond the curtain wall the glacis will continue 50 feet ending in a shallow toe wall at R. L. 741.5, four feet below lowest water surface and 1 foot below lowest bed. This section will be porous masonry yet heavy enough to stand the action of the standing wave that will form on it.

34. Beyond the end of the glacis there will be a flexible apron 35 feet wide and 6 feet deep, of this width a 15 feet portion will be concrete blocks $4' \times 4' \times 2'$ laid practically on edge and the rest stone.

Four feet deep would be sufficient.
H. W. M. IVES,
2nd September 1919. Chief Engineer.

This method of laying the concrete blocks has not been adopted before in connection with Punjab weirs but it is merely the application of what is done in harbour works.

With concrete blocks laid flat any shift is bound to expose an open space whereas by the method now adopted the blocks are not covering their maximum area so that a considerable shifting can take place before an open space is exposed.

35. The weir is divided from the undersluices by the divide wall upstream already described, downstream a divide wall is provided of a length sufficient to ensure that the swirl caused by working the undersluices to their maximum capacity for scouring purposes, shall not disturb the weir talus.

36. Alongside this divide wall a fish ladder is provided of ample proportions with a water surface slope through it of 1 in 20 so as to give an easy passage to the fish.

A similar divide wall and fish ladder is provided between the 24th and 25th bays of the weir on the right flank, the only difference being that the divide wall upstream does not go beyond the weir floor.

37. Downstream of the four right flank bays of the weir the protection is strengthened, since the weir will always be opened first in those bays when the greatest fall in water surface will exist.

38. The piers of the weir have been made 10 feet thick of sufficient length to carry the steel superstructure for the counterbalanced Stoney gates (60 feet span) and also a girder road bridge; this length will be sufficient for stability.

No provision is made in the Project for the cost of this girder road-bridge on the piers as it is not essential for the weir as an irrigation work.

The cost of the bridge has been estimated to be 23 lacs and if the cost were contributed from Provincial funds, it could be quite easily erected.

39. Every fourth pier of the weir is increased from 10 feet to 12 feet thick and steps will be made from the upstream noses down to the weir floor, the want of which has been felt at similar works already built.

Downstream of these piers, foundations to the level of the bottom of the curtain wall are carried as far as the toe wall at the end of the glacis. These foundations are for divide walls to prevent currents developing along the talus of the weir, only two of these walls will be constructed as it is considered that they will suffice but the three others can be added later if required on the foundations provided.

TRAINING WORKS.

40. The river hugs the right bank at the site and the afflux caused by the weir will flood but little extra land on that bank. It was first proposed to put the weir further away from the right bank so that it could be completed without encroaching on the existing river bed and give a correspondingly shorter main line, but the Chief Engineer considered it preferable to avoid the necessity of having to divert the river and altered the location to that shown on the plan.

41. On the left bank an upstream Marginal Bund is required to prevent the large area of highly cultivated "Bet" land being submerged.

This bund is aligned so as to pass outside the villages of Khaira and Nurpur and avoid intersecting the Budha Nala until it is crossed close to the high bank at Baranhara. Baranhara is only about 4 miles from Ludhiana near the old District Road from Ludhiana to Ferozepore.

It would be desirable to arrange with the District Board at the time of construction to metal this 4 miles length and thus link up the patrol road along the bund with Ludhiana thereby giving efficient communications between the Headworks and Ludhiana. Communications in this part of the District are at present very poor.

42. A regulator of 20 feet span is provided in the bund to permit of a regulated supply being run down the existing Budha Nala if necessary. It will also be wide enough to pass a barge if desired.

The discharge of the Budha Nala at the Railway crossing near Ludhiana is estimated to be 3,000 cusecs. The channel has been cross sectioned from Ludhiana to the Head of the diversion.

43. The details of the Marginal Bund and the Budha Nala Diversion are shown on the longitudinal section in the Folio of Plans.

The diversion channel will have a bed width of 50 feet and a slope of 1/5,000; the outfall in the river will not be masked and the continuous clear water flow of the Budha Nala will maintain an open channel, at no time does the Budha Nala carry any appreciable quantity of silt as its catchment is so flat.

The maximum flood level above the weir is taken at R.L. 762 (see para. 15). The tops of all bunds are given a clearance of 5 feet above that flood level.

The river in high flood will have a slope of 1/3,333 so that the top level of all works above the weir is fixed on a flood level calculated from that slope and the distance of the place in question above the weir.

44. The Upstream Left Bank Marginal Bund is well retired from the river and as soon as work is started the whole area between the bund and the River Bank must be planted out with willows to obviate any likelihood of the river embaying enough to endanger the safety of the bund. The bund to begin with will be subject to wave action from ponded up water and provision has therefore been made for laying 1 foot of quarry refuse on the face of the bund up to 3 feet above pond level for a length of 20,000 feet.

The section of the bund provided is 30 feet top width, 3:1 river face slope, 2:1 back slope. All the earth will be taken from the river side. A berm of considerable width will be left between the borrow-pits and toe of the bund. To prevent the borrow-pits developing into a channel of cross-bars must be left, this with the planting of willows will cause the area below pond level to silt up rapidly.

On no account should the borrow-pits be put behind the bund as was done at Merula against the wish of the local officers.

45. Before the river reaches the weir, it is necessary to fix its direction of approach to the weir in the first position it is meant to adhere to.

This is obtained naturally at Rupar by a high bluff on the right bank, and the fact that the river is turned on a curve keeps the main stream always on spurs Nos. 3 and 2. To control the river approach to the Aliwal Headworks, two spurs have been provided to anchor the river on the centre line of the weir some distance upstream of it.

46. The distance between these spurs is a matter of great importance. If they are too far apart the river will be able to pass between them obliquely and its stream will not be held in direction.

The narrowest width of the river near Rupar are —

At Patial 4 miles above Rupar 1,100 feet.

Below Rupar Weir 1,900 feet.

There are no spills at these two sites, which are natural channels.

Just above the Aliwal Headworks site, at Sanghowal and Burj Hassan the natural river channel has a width of 1,600 feet with spills in high flood.

The width of waterway on the two Railway Bridges is —

Phillour	...	2,000 feet.
Sultanpur bridge	...	1,800 ..

At Phillour the river does not run as desired between the guide banks normal to the bridge but diagonally.

At the Phillour Bridge the stone in the guide banks has been practically undisturbed since the bridge was shortened and the river contracted.

The width fixed for the distance between the two spurs at Aliwal is 1,800 feet, this will give no abnormal contraction to the river or cause any acute action on the spurs and it might be further reduced.

47. The left bank upstream spur flank is formed by the upstream left marginal bund already described. This spur is linked up to the regulator and in reality becomes the head of the upstream left guide bank.

It is desirable to pitch the length of the left bund between the spur and the head regulator, so that there shall not be any tendency for a sudden embayment, due to scour, to occur. throwing excessively silt-charged water into the head regulator.

On the right bank such a continuous pitched guide bank is unnecessary.

48. It was at first proposed to put the flanks of the two upstream spurs 7,500 feet upstream of the weir, but higher authority decided that if the upstream noses of the spurs were placed 5,000 above the weir it would suffice.

At the same time the length of the upstream right guide bank was cut down from 1,600 feet length to 1,000 feet length.

49. The heads of the spurs have been designed on the basis of experience at Rupar and Suketar II. The whole action comes on the front corner of the head and little or none at the back, so that the apron has been narrowed after passing the axis of the head. In the long straight lengths the aprons have been made 30' x 4' as experience on Upper Jhelum Canal and the Budki torrent on the Sirhind Canal shows that little action takes place on a straight guide bank.

50. Where the guide banks approach the weir the aprons are correspondingly increased. The left flank guide bank apron has been increased to 40 feet for a distance of 1,000 feet upstream of the sluices for security against a strong draw from the sluices when scouring. On the right flank the apron has not been tapered down to 30 feet as there will be the continual draw due to the working of the weir from the right flank.

51. The aprons are placed as low in excavation as possible to maintain the existing slope of the river bed in the slope of the aprons, there will be little pumping involved in doing this, but the lower the apron is placed the more efficient it is. This procedure was adopted on the Upper Jhelum Canal with considerable saving, an apron at a higher level would have to be widened $2\frac{1}{2}$ feet for every foot in rise.

There should be no pumping required in laying these aprons, which should go down to as far as the water in the soil will permit during low river period.

H. W. M. IVES,
Chief Engineer.

Dated 2nd September 1919.

In the case of the left bank marginal guide bank the top of the apron will have to slope down to join the undersluice floor at the same level and in that case the pumping will be more.

The present general level of low water at the weir site in the winter is R. L. 745 so that the pumping or unwatering will not be excessive.

52. Downstream of the weir a left bank marginal bund is provided to enclose the station area and keep the river away from the canal. The bund meets the canal just above the Budha Nala syphon.

53. Downstream bunds, 1,000 feet long, are provided on both flanks of the weir to lead the water away from the vicinity of the work without damage.

54. The river is to be anchored at its approach to the weir between two spurs, and two similar but lighter spurs are provided 5,000 feet downstream of the weir at the same distance apart as in the case of those upstream.

In any case the downstream left bank marginal bund needs protection and one of these two spurs fulfils the purpose.

The other spur will cause the two separate channels that form from the flanks of the weir to unite on the centre line of it.

Were the right bank spur omitted, the river must fall away to the right and the channel from the undersluices would thus become less efficient.

Similar undertakings of Khanki have shown that the spur constructed downstream on the side of the undersluices masks the flow through them and prevents scouring action required through them.

H. W. M. IVES,
Chief Engineer.

2nd September 1919.

The necessity for creating a condition below the weir which will force the streams from both flanks of the Headworks into one contracted channel opposite the middle of the weir seems to be established by a consideration of the river surveys of Rasul for the last 12 years in connection with its silt history, and the fact that such conditions exist naturally at Rupar.

The principle is that a deep channel is maintained below the weir on the right flank by the surplus river supply. On opening the undersluices for pocket scouring an abnormal silt charge is carried by the water passing the sluices, when this water gets into the open river downstream owing to the decrease in velocity it deposits a great deal of its silt burden. This deposition of silt tends to shoal up the channel from the undersluices on the left flank and force the channel from the right flank of the weir further away to the right, thus lessening the effective scouring capacity of the sluices. This point has not been considered much in the past and the idea may be a new one.

If the channels from the flanks of the weir are constrained to meet a short distance downstream of it, during pocket scouring the excess silt will be deposited in the channel down which the water from the right flank of the weir will pass during normal working of the Headworks.

This water from the right flank of the weir will always endeavour to carry its full silt charge and thus maintain as clear a channel as possible reasonably near to the undersluice outfall which is the condition it is always desirable to maintain for efficient working of the Headworks.

CHAPTER IV.

Description of Works.

A.—PRELIMINARY.

1. Provision is made under this head for surveying and laying out the centre line, land width of the channels and for clearing Boundary Roads.

2. Provision is also made for carrying the share of the cost of the preparation of the project charged to "43.—Minor Works and Navigation," which will be written back as a debit to the project and credit to Provincial Funds on the sanction of the project.

3. Under Headworks provision is made for further surveys and discharge observation prior to construction.

4. Provision is also made for an inauguration ceremony, as was done on the existing Sirhind Canal, when it was opened; since Native States will also share in the benefits of this Canal, it will be desirable to have funds to arrange for a ceremony befitting the dignity of the Supreme Government.

No other canal projects have had such a provision made in them.

H. W. IVES,
Chief Engineer.

2nd September 1919.

B.—LAND.

5. Land has been provided for all the channels in accordance with the type sections in the Folio of Plans as given in column 3 of the List of Masoury Works (Appendix A).

6. The rates for land are taken from the figures supplied by the Deputy Commissioners of the various British Districts. In the case of land in Native States, the rate has been fixed the same as in the adjacent British Districts or the mean of the two British Districts between which the State lands lie.

7. Provision has been made for the cost of land for a Superintending Engineer's residence and office as well as for Executive Engineers and Sub-Divisional Officers, the details of which are shown in the estimate.

8. For Rest Houses a provision of 5 acres of land has been made for each Compound.

9. When construction work on the Project is about to start, the question of acquisition of land in the Native States will be of first importance needing the cordial co-operation of the Phulkian States to avoid unnecessary delay.

The land in the Phulkian States will be acquired under Clauses 40, 29, 7, 30 of the Sirhind Canal Agreement of 1873.

10. For Headworks the land to be acquired is shown on the 4" to 1 mile River Survey map in the Folio of Plans. All land in the river bed up to Sangawal outside the left bank marginal bund will be acquired as it will be subject to continual flooding.

11. The rates given by the Deputy Commissioners for compensation values of land are abstracted in the accompanying statement. The high values are worthy of note when it is remembered that at the time of the construction of the existing Sirhind Canal land was acquired for Rs. 40 an acre.

STATEMENT SHOWING RATES OF LAND REQUIRED FOR CHANNELS IN VARIOUS DISTRICTS.

District.	Tehsil.	Description of land.	Rate per acre.	Land revenue per acre.
			Rs.	Rs. a. p.
Ludhiana ... Deputy Commissioner's No. 2589 of 15th November 1918.	Ludhiana ...	Bet—Bed of River ...	100	0 1 0
		Barani ...	180	1 1 0
		Chahi ...	437	1 5 5
	Jagraon ...	Bet—Bed of River ...	50	nil.
		Grazing land in river tract ...	105	0 1 0
		Barani ...	196	2 0 0
		Chahi ...	450	4 0 0
		Dhaya Nicha—		
		Barani ...	225	1 12 0
		Chahi ...	575	{ Niain 4 4 0 Khalis 2 8 0
		Ludhiana ...		
		Jungle—		
		Dakar ...	200	1 4 0
		Rosli ...	250	0 2 0
		Bhur ...	100	0 6 0
		Nahri Niain ...	550	1 12 6
		Nahri Khalis ...	400	1 4 0
Ferozepore ... Deputy Commissioner's No. 9130 of 28th October 1918.	Moga ...	Chahi ...	550	2 0 0
		Nahri ...	500	1 12 0
		Barani ...	400	1 6 0
	Ferozepore ...	Nahri ...	500	1 4 6
		Barani ...	350	0 13 6
	Fazilka ...	Nahri ...	250	0 8 0
		Barani ...	150	0 5 6
Hissar ... Deputy Commissioner's No. 3603 of 6th October 1918.	Sirsa ...	Barani ...	80	0 3 6
		Banjar ...	50	0 3 6

D.—REGULATORS.

12. All Regulators on the Main channels of both canals in the Project have been designed for counterbalanced Stoney gates of 20 feet span. This will give a standard groove and lifting gear thus reducing the cost and increasing the rapidity of construction. The only variation will be a slight difference in the height of gates, which should not lessen the efficiency of economical production as the only items to be changed, will be the height of the skin plate and the end roller beams in the gates.

The advantage of having a standard lifting gear, so that spares can be kept and replacements easily made, will be seen by reference to the statements of both canals which give the details of the number of spans, and shows that 70 gates of 20 feet span will be required.

13. *The Main Line Upper Head Regulator.*—The drawing of this work is found in the Folio of Plans "Headworks" as although the work is charged to the Main Line, it is designed in connection with the Headworks.

The leading dimensions of the Regulator have already been fixed in Chapter III.

Apart from the fact that it is a skew Regulator there is nothing novel in the design of sixteen 20-feet spans.

The canal bed being 6 feet above Pocket floor such a heavy floor downstream of the Regulator as usual is not required.

The length of the wing wall between the Regulator and the Undersluices was determined by the necessity of getting a free and open approach to the roadway bridge over the Undersluices.

In this wing wall an arched opening has been provided so that at any time when desired hydro-electric power can be obtained by drawing water from the Pocket and tailing it into the canal or below the sluices as may be possible at the time.

14. The top of the masonry crest of the Regulator is $4\frac{1}{2}$ feet above canal bed or R. L. 754. Behind this a rising sill 4 feet high is provided, which will enable regulation to be done without lowering the upper gates.

To close the canal 4-feet gates are provided which will work in the same groove as the rising sill and close off up to the maximum probable flood level 862 R. L.

15. As all the training works have a free board of 5 feet above probable ultimate flood level, instead of putting in a higher gate, a steel shield is provided consisting of steel channels bolted to the upstream face of the grooves with a skin plate rivetted on.

This is virtually a fixed gate and will materially lessen the weight and cost of the moving gates of the Stoney counterbalanced pattern provided.

16. The arches have been designed with a 90° curvature springing 2 feet above full supply. This gives a sufficiently high structure to carry the gearing for the gates without a steel superstructure.

17. *Head Regulators of Main Line Lower and Grey Canals Feeder at Sidhwan.*—These are combined and have nine and two spans of 20 feet respectively, the details of the design are given on the drawing in the Folio of Plans.

The arches of this and all other Regulators have been designed with a 90° curvature springing 1 foot above full supply upstream of the regulator; this gives a platform high enough to carry the gearing without a steel superstructure.

18. There is no fall in water surface through the Regulator in the Main Line which is only provided to hold up the supply in the Main Line for the Grey Canal Feeder. This will only be necessary under abnormal conditions, because at full supply there is a working head of 4.3 feet into the Feeder. A bridge for the District Road at this site is required in any case.

It is possible that the Regulator may be required to hold up water over the lining on the canal bed if there should be a rise or spring level above that at present existing.

At the time of construction it might be desirable to build the regulating bridge complete as designed, omitting to put in the gates and gearing until such time as the necessity for them arose.

19. *Head Regulator of Abohar-Bhatinda Feeder and Abohar Branch at Daudhar.*—These Regulators are combined and have 5 and 4 spans of 20 ft. respectively, both take off at about an angle of 45° to the centre line of the Main Line. The details of design are given on the drawing in the Folio of Plans.

20. The bed of the Abohar Branch takes off flush with the tail of the Main Line after the alterations detailed under alignments have been put into effect which gives a fall in water surface through the Regulator of 1 ft.

There is a drop in bed level from the tail of the Main Line into the Feeder of 76 ft. and a fall in water surface of 1.76 ft.

21. As this work will have to be done as a canal closure work and spring level is high, well foundations have been provided.

22. As the construction Railway Line will have to cross the Abohar Branch a 14 ft. roadway has been given to the Regulator for that branch so that a separate bridge will not be necessary for the Railway Line.

23. The Wadni Distributary will be taken across in a steel aqueduct on the piers downstream of the Regulator, the net cost of the Regulator only is debited to this head. The extra cost involved in taking the distributary across is debited to "G.-1—Canal Crossings."

24. The regulator at the head of the Sutlej Navigation Channel, which takes off the Abohar Branch between Daudhar and Gholia, will require alteration for which a lump sum of Rs. 5,000 has been provided.

25. **Head Regulator of Phul Feeder and Bhatinda Branch at Dhipali.**—These two regulators are combined and have 4 and 2 spans of 20 ft. respectively. The Phul Feeder is practically in line with the tail of the Abohar-Bhatinda Feeder, which cuts the Bhatinda Branch at an angle of about 50°.

The details of design are given on the drawing in the Folio of Plans.

26. The bed of the Bhatinda Branch takes off flush with the tail of the Abohar-Bhatinda Feeder after the alterations detailed under alignments have been put into effect which gives a fall in water surface through the Regulator of 1.4 ft.

There is a drop in bed and full supply levels from the tail of the Abohar-Bhatinda Feeder into the Phul Feeder of 75 ft.

The arrangement of the details of these two regulators is similar to those at Daudhar, only without well foundations owing to spring level being low at the site.

27. It was not feasible to arrange to take the Railway Line over the Bhatinda Branch Regulator but as the channel has a bed width of only 54 feet, a temporary bridge can easily be provided.

28. The new Mari Distributary to supply the existing Mari Distributary and the irrigation cut off by the Feeder, will be carried across the piers downstream of the Phul Feeder Head Regulator, as was done in the case of the Wadni Feeder Distributary crossing the Abohar-Bhatinda Feeder Head Regulator.

29. **Head Regulators of Rori (A 9) Feeder and Bhatinda-Bikaner Feeders at Rampura Phul.**—These two Regulators are combined and have two spans of 20 ft. each.

The Rori Feeder takes off at an angle of 13° to the left and the Bhatinda-Bikaner at an angle of 44° to the right.

The details of design are given in the drawing in the Folio of Plans.

30. There is a drop of 2.2 ft. and 3.2 ft. in bed and water surface respectively into the Bhatinda-Bikaner Feeder and a drop of 1.5 and 2.5 in bed and water surface into the Rori (A 9) Feeder.

This will permit of satisfactory rotational working without heading up at the tail of the Phul Feeder and permit of increased supplies being run at any future date without upsetting the régime of the channels.

31. It was not possible to arrange the design so that the Construction Railway would be able to pass over the Head Regulator of the Bhatinda-Bikaner Feeder as the regulator is close up to the Railway Line.

As a matter of fact by the time it is desired to run water in the Bhatinda-Bikaner Feeder, the Rori Feeder should be completed and the Railway Line picked up and removed elsewhere so that the necessity for a bridge should never arise.

32. The new low level Phul Distributary will have its head in the wing wall between the two Head Regulators of the Feeders. To get in suitable approaches, a considerable length of wing wall is required between the two Regulators. There is a fall in full supply of over 3 ft. into one Feeder and nearly as much in the other. An arched opening is therefore provided so that at any time should it be desired to work mills from this fall, no heavy alterations would be required; the water could be tailed into whichever channel gave the greatest difference in water surface.

33. The tail of the high level Phul Distributary to supply the irrigation cut off between the two Feeders, will be carried across the piers downstream of the Rori Feeder Head Regulator, as described already in the case of the Wadni Feeder Distributary crossing of the Abohar-Bhatinda Feeder Head Regulator.

34. **Regulator mile 28-4,000' of Rori Feeder.**—This being a small Regulator three 10-ft. spans are provided, the same as will be used in the Chautala Distributary taking out above the Regulator. The drawing of this simple straightforward design is bound in the Folio of Plans and calls for no comment.

35. **Regulators for Bikaner Main and Border Branches at Dabwali.**—These Regulators are combined and have two and one spans of 20 ft. respectively the Main and Border Branches taking off at angles of 45° to the left and right respectively.

The details of the design are given in the drawing in the Folio of Plans.

There is a drop of 2 ft. in bed and full supply into the Main Branch and a drop of 5 ft. and 7 ft. in bed and water surface into the Border Branch.

This will permit of satisfactory rotational working without heading up at the tail of the Feeder and permit of increased supplies being run at any future date without upsetting the *régime* of the channels.

36. A head for a distributary is provided in the wing wall between the two Regulators so that a distributary can be constructed if required, to irrigate the area of British territory between the two branches, by water taken from the tail of the Feeder instead of by syphoning British Distributaries under the Branches. As mentioned elsewhere, it is desirable that this condition should be provided for in the agreement that will eventually be made with Bikaner State.

37. In addition to the Distributary head, a head for a power channel is provided in the wing wall so that power can be economically developed when needed. This is referred to under "J. Mills."

38. Regulating Bridges will be required in the Bikaner Main Branch at miles 18 and 32-3,000 ft. No detailed designs have been made out for these works, but the cost has been taken by proportion from the Regulator designed for mile 28-4,000 ft. of the Rori Feeder.

E.—FALLS AND WEIRS.

39. There are no falls on the Feeders owing to the nature of their alignment which is designed to keep the maximum command for the Rori-Chautala tract.

40. **On the Grey Canal Feeder** as designed, there are four falls of from 3 to 7 ft. which have not been designed in detail but the cost taken from that of similar works on the Gujrat Branch on the Upper Jhelum Canal.

41. **On the Bhatinda-Bikaner Feeder**, there are two substantial falls.

8.5 ft. at mile 5-4,000'

9.0 ft. at mile 22-2,000'

A detailed design has been taken out for one of these which is given on the drawing in the Folio of Plans.

The design has been made with no cistern as in the American practice and since the channel is concrete lined there will be little, if any, fear of trouble from scour downstream. The fall has been designed for gates which can be put in when power is developed.

A small 2.5 ft. fall at mile 15 has not been designed in detail; but the cost estimated by proportion from the design for the 9 ft. fall.

42. *On the Bikaner Main Branch*, there are two small falls which have not been designed in detail, but the cost has been estimated by proportion from the falls designed for the Bhatinda-Bikaner Feeder.

43. *On the Abohar and Bhatinda Branches* the alterations to the reaches taking off from the new Lower Sirhind Canal involve lowering the crests of the Gholia and Sadhana Falls. No detailed designs have been prepared but after an inspection of the existing works and drawings a suitable lump sum provision has been made.

F.—RIVER AND HILL TORRENTS.

44. *Main Line Upper*.—Syphon for Budha Nala mile 2-1,000'. In Chapter II, para. 3, it was shown that the maximum discharge that might be expected on the completion of the upstream marginal bund would be 600 cusecs.

The detailed design bound in the Folio of Plans, provides for three steel tubes of 8 ft. diameter embedded in concrete under the canal bed, the rest of the length of the barrels with the wing walls, being of normal brick-work.

At the time of construction these steel tubes may be replaced by re-inforced concrete and an economy effected.

The work involves pumping for which a provision of Rs. 5,000 has been made.

45. *Main Line Lower*.—Four inlets are provided of the type designed for the Lopon Drainage on the Abohar-Bhatinda Feeder.

46. *Abohar-Bhatinda Feeder*.—Inlet for Lopon Drainage mile 2-2,000 ft. The detailed design bound in the Folio of Plans provides for five spans of 8 ft. the patrol road being carried over on arches. The floor of the inlet is taken through from canal bed at the same level, up to the face of the drop wall.

The drainage will only carry water in times of exceptional rainfall when the demand on the canal will automatically cease so there will be no difficulty in disposing of the water let into the canal.

Two other small inlets are provided on this Feeder more as a precaution than a necessity.

47. *Bikaner Main Branch*.—Four syphons of 5 ft. diameter barrel for the extinct Nala or depressions are provided, although no openings are left in the Railway Line, this is done by way of precaution.

G.—BRIDGES.

48. These are all according to type. The abutment with half span and one pier with two half arches have been designed and estimated in detail for two spans of 20 ft. and 25 ft. and two depths of supply 8 ft. and 10 ft., the costs for other conditions of span and full supply depths have been obtained by interpolating and extrapolating from the estimates obtained. The results are given in Appendix B, 14.

For the Bridges in the first 14 miles of the Main Line an allowance has been made for wet foundations on account of high spring level.

49. Appendix B 11 shows that three spans of 20, 22, 24 ft. only have been utilised, this is far more satisfactory than having spans differing by a few inches for the various bridges and permits the use of standard steel centerings

which will lead to considerable economy and rapidity of progress. On the Lower Sirhind Canal there will be 122 bridges of 403 spans, to be built only of the three widths given above. On the Upper Sirhind Canal there will be a further 441 spans. Work in the Drawing Office will also be materially lessened.

50. All bridges have been provided as road bridges, because experience on the Sirhind Canal shows that the development of Irrigation calls for better communications, and foot bridges on that system are being gradually replaced by road bridges.

The rules regarding the widths of roadway given in Article 10 of Irrigation Manual of Orders have been complied with.

51. The following Railway Bridges will be required on the main channels :—

Main Line Lower, near Ajitwal Railway Station for the Ludhiana-Ferozepore Railway, broad gauge line.

Phul Feeder, near Rampura Phul Railway station, Rajpura-Bhatinda Railway, broad gauge line.

Rori Feeder, near Maur station on the Bhatinda-Jakhal Railway, broad gauge line.

Bhatinda-Bikaner Feeder, near Katar Singhwala Railway station on the Bhatinda-Jakhal Railway, broad gauge line.

Bhatinda-Bikaner Feeder, near Bhatinda station on the Bhatinda-Sirsa Railway, metre gauge line.

Bhatinda-Bikaner Feeder, near Sangat station on the Bhatinda-Hanumangarh section of the Jodhpur-Bikaner, metre gauge line.

The provision for Railway Bridges has been made at the rate of Rs. 400 per foot of bed, the figure being obtained from those given in the revised estimate of the Triple Canal Project.

G. 1.—CANAL CROSSINGS.

52. No project heretofore submitted has involved new main channels cutting across existing Irrigation channels. In this Project however very heavy expenditure is incurred on the Lower Sirhind Canal in connection with such works and all costs on this account are put into a new sub-head G. 1. in accordance with Superintending Engineer's orders.

Details of all the channels to be crossed which are not supplied by the Lower Sirhind Canal are given in Appendix B. 9.

53. The arrangement for taking the Jagraon Distributary across the canal is different to all the others. There is so much clear headway that it can be carried across in a masonry aqueduct and the roadway then carried on top of the aqueduct. In all other cases the headway is insufficient to permit of such a procedure being adopted.

54. Where a clearance of 1 ft. or more can be obtained between the bed of the distributary and the full supply of the main channel, the distributary has been taken across in a steel trough aqueduct on the piers of the regulators or bridges lengthened as necessary.

In a few cases where the section of the trough would be very small a steel tube is proposed.

55. In those cases where the necessary 1-ft. clearance could not be obtained, the distributary has been shown as being syphoned under the canal. The syphon has been designed as a steel tube embedded in concrete for the length under the canal bed where there would be an unbalanced head of water under the banks it is continued as an ordinary masonry barrel.

56. When the works come to be carried out, it is probable that the aqueduct and syphon designs will be modified and reinforced concrete used in place of the steel work estimated for, which will probably lead to economy in first cost and upkeep.

Drawings of the various works which involved separate designs are given in the Folio of Plans.

H.—ESCAPES.

57. No provision is made for any escape as owing to extending telegraphic communications there is not now the same necessity for them as in the past. There is however the existing Sutlej Navigation Channel used as an escape which will give relief at Daudhar when required.

If found desirable an escape could be made from the tail of the Rori Feeder into the Ghaggar Nala.

J.—MILLS.

58. The only falls of any magnitude which would be of use for power are those referred to above under "E.—Falls and Weirs".

59. The falls on the Grey Canal Feeder would not be suitable for power development as the channels run in the Kharif only.

60. On Bhatinda-Bikaner Feeder the 8.5-ft. fall at mile 5.300 ft. would give about 2,000 water H. P. at full supply and is close to Lahra Mohabbat Railway Station on the Bhatinda-Dhuri Line, the next station to Rampura Phul Mandi. The 9.0 ft. fall at mile 22-2,000 ft. which would give about 2,000 water H. P. at full supply is on the R. M. Metre Gauge Railway from Bhatinda to Sirsa and only 4 miles from Bhatinda.

When preparing the final designs for the falls, it would be desirable to arrange them so that when the demand for power arose the masonry work would need no alteration.

A provision has been made of Rs. 30,000 at each fall which would cover the cost of putting in a ten stone country mill or could be utilised for elaborating the masonry works to provide for the installation of turbines for power development.

61. At the tail of the Bhatinda-Bikaner Feeder there is a fall of 7 ft. in water surface into the Border Branch. This would give 362 H. P. at full supply which could be efficiently used at Dabwali Mandi only 2 miles away, on the Jodhpur-Bikaner Railway. A provision of Rs. 15,000 has been made for utilising this fall for power.

62. On the Bikaner Main Branch there is a 9.0 feet fall in water surface at the regulator at mile 32-2,000', near Hanumangarh on the Jodhpur-Bikaner Railway. This fall at full supply would give about 250 water H.P., which could be efficiently utilised for the Palace at Hanumangarh and the Mandi which is bound to develop with the advent of perennial irrigation in the tract.

63. At the tail of the Rori (A-9) Feeder the Bara Gudah Distributary takes off with a fall of 7 ft. in water surface, provision is made here of Rs. 10,000 for a small mill.

64. Where the Bara Gudah Distributary crosses the R. M. Railway from Bhatinda to Sirsa there will be a fall which could be efficiently utilised in a small mill and for which a provision of Rs. 10,000 is made.

65. It might be desirable to utilise the fall into the Bara Gudah Distributary from the tail of the Rori Feeder to pump water on to the high land in the vicinity which cannot be irrigated by flow as it is impossible to increase the command above that now obtained in the Rori Feeder.

K.—BUILDINGS.

66. Provision is made as shown in tabular form in the estimate under "K.—Buildings" and appears to need but little explanation.

The provision for temporary buildings is lighter in proportion to the total than in the case of previous projects. This is due to the experience gained which shows that the construction of temporary buildings except in very few cases, for a canal which is permanent, in the long run, involves Government in far greater expenditure.

L.—EARTHWORK.

67. The estimates have been taken out in detail for the channels in accordance with the longitudinal and cross-sections approved and bound in the folio of Plans.

The original detailed estimates are bound and filed in the Project records and are not reproduced.

68. The rates for earthwork have been fixed at—

		Rs.	% c. ft.
Main Line Upper and Lower	...	10	"
Grey Canal Feeder, first 10 miles	...	8	"
Remainder do. do.	...	6	"
Abohar-Bhatinda Feeder	...	8	"
Phul Feeder	...	7	"
Rori (A-9) Feeder	...	6	"
Bhatinda-Bikaner Feeder	...	7	"
Bikaner Branches	...	6	"
Alterations, Abohar and Bhatinda Branches	...	6	"

These rates have been fixed by consideration of the local conditions of soil, and existing rates and what may be expected to hold when the Project is put in hand.

69. The estimate only provides for earthwork to the surface of the lining in case of lined channels. The cost of excavating earth replaced by lining being provided for in the lining rate. Due allowance has been made for this extra earth in fixing spoil banks and land widths.

L. 1.—LINING.

70. This is a new head, no Project heretofore having been prepared in which provision was made for lining channels and it has been deemed desirable to maintain the costs of this work under a separate head as the amount involved is the heaviest of any head.

71. The Main Canal and Feeders will be lined from the head at Aliwal to the tail of the Phul Feeder 58.8 miles below this point the canal bifurcates. The Rori Feeder 34.4 miles long will be lined.

72. The Bhatinda-Bikaner Feeder 46.2 miles long will be lined. From the tail of this Feeder the Bikaner Border Branch for the 9 miles length in British territory will be lined.

73. The Bikaner Border Branch for 9 miles runs in British territory and will be lined in any case. In the estimate provision is made for lining the Bikaner Main Branch down to the tail, 53 miles, as the conditions are so favourable for lining, the soil being light and the alignment runs parallel to the Railway line the whole way giving easy transport of materials.

74. The new Bhowani Wadni Feeder Distributary will be lined, but the whole of the cost of this channel is a charge to "G. 1.—Canal Crossings" in connection with the Abohar Branch alterations.

M.—PLANTATIONS.

75. Provision is made for lines of avenues along the patrol and boundary roads of all main channels, also marginal bunds at Headworks, at Rs. 100 per mile of avenue.

76. Provision is made for sowing broadcast all the spoil banks and any suitable open spaces that occur, not occupied by roads or banks, within canal land.

Great care will have to be taken in the case of lined channels so that no trees are planted near enough to the canal for the roots of the trees to damage the lining.

77. An allowance has been made for plantations at Divisional Headquarters.

78. For Rest-houses a sum of Rs. 500 has been provided for laying out plantations, hedges, etc.; the cost of maintenance of gardens is included in the allowance under "P. A. Maintenance."

79. For Headworks station site a provision of Rs. 10,000 has been made.

80. As mentioned under the design of Headworks as soon as the Upstream Marginal Bund is completed, the area between it and the river will be planted out with willows, so that any tendency of the river to sway out of its existing channel will be controlled. Willows were greatly used in connection with the River Chenab training works at the Wazirabad Bridge from where the necessary cuttings for this site can be obtained.

A provision of 2,500 acres at Rs. 25 per acre has been made on this account.

O.—MISCELLANEOUS.

81. Boundary pillars and distance marks have been provided as usual.

82. Provision has been made for draining banks and spoil of all the channels (excepting the Bikaner Branches where the rainfall is small) and the bunds at Headworks, this is a most necessary provision and was omitted in the Triple Canal Project.

83. Embedded bench marks have been provided for at every two miles on the alignment, the fixing of these at once on construction commencing will save much trouble later, as found from experience on the Triple Canal Project.

84. For experiments and conservancy two very necessary items, lump sum provision has been made.

85. Fencing Rest-house Compounds and Divisional Headquarters Stations has been provided for and a lump sum allowed on each channel for unforeseen miscellaneous charges.

P.—MAINTENANCE.

86. Provision has been made from analogy with the Triple Canal Project as given in the abstract of the estimate.

Q.—LOSSES ON STOCK.

87. This is a new head added to Projects in 1913. Formerly such charges were included under O.—Miscellaneous, a small lump sum is however provided under this head to justify its existence.

3.—DISTRIBUTARIES.

88. The actual costs of Distributaries constructed on the three canals of the Triple Canal Project were obtained, together with the figures of areas commanded, irrigation expected, head capacities and length of channels. These figures were investigated to find out which gave the most reliable basis for estimating.

From the figures for the Upper Chenab Canal it was found that the gross area commanded gave a practically constant figure of Rs. 3 per acre total charges, of which about 8 annas per acre was the share of cost of land coming under the Distributaries.

On the Lower Bari Doab Canal the cost of land is negligible and consequently the rate was lower, viz., Rs. 2 to Rs. 2-8-0 per acre.

89. Provision has been made at Rs. 3 per acre of gross area within irrigation limits for all Distributaries except those in Bikaner for which a rate of Rs. 2-12-0 has been fixed since land is cheaper in that tract.

5.—SPECIAL TOOLS AND PLANT.

90. This is a new head introduced for the first time in this Project under the orders of the Government of India in Circular No. 1764 A., dated 1st November 1918.

91. Provision is made for Railways under this head. A line will be required from Ajitval station on the Ludhiana-Berozapore Railway to the

Aliwal Headworks 21 miles. This line is charged to Headworks as in other Projects. A permanent line will be required to Aliwal for maintenance purposes but it will not be necessary to keep the line from Ajitwal. It may be that an open line will be taken from Jagraon across the river below the weir at Aliwal to Nakudar, thus giving what appears to be a very desirable new open line, from Jullundur to Jagraon, which might be continued to Bhatinda, so giving a chord line in a tract which is greatly in need of improved Railway communications. This line could be made from the permanent-way material, which would become available when the temporary canal construction railways were no longer required.

92. A temporary line (40 miles long) from Ajitwal station to Rampura Phul station on the Rappura-Bhatinda line is required for the carriage of materials from Ajitwal to Daudhar for the lower reach of the Main Line 8 miles, thence to Dhipali for the Abolur-Bhatinda Feeder 25 miles, and thence to Rampura Phul for the Phul Feeder 7 miles.

93. A temporary line is also required from Rampura Phul station to Maur station on the Bhatinda-Jakhul Railway, a distance of 16 miles, for carriage of materials for the Rori (A-9) Feeder, this would have to be continued beyond Maur to the tail a distance of 18 miles.

The Rori Feeder will be the first portion of the work to be pushed through to completion, and the 34 miles of permanent-way will be available for use on the Upper Sirhind Canal.

94. For works on the Bhatinda Bikaner Feeder, as the alignment runs beside the railway for 12 miles, it will be unnecessary to construct a temporary railway, sidings from the existing line will suffice; a temporary broad gauge line will be required from mile 12 to mile 20 where the Bhatinda-Jakhul (Southern Punjab) Railway is crossed. Below the Southern Punjab Railway to Sangat a metre gauge line 11 miles in length will be run from Sangat station on the Jodhpur-Bikaner Railway. From Sangat to the tail of the Bhatinda Bikaner Feeder the channel is aligned along the railway line so sidings only will be required.

95. For the Bikaner Border Branch 9 miles of temporary metre gauge line will be required, which will afterwards be utilised for the sidings for the Bikaner Main Branch which runs alongside the railway line for 53 miles.

96. The cost of the Railway line to the Nalagarh Quarries from Ghanauli on the Rupar-Bhakra Railway is a debit to the Project and Rs. 1,75,000 are provided for under this head against the Headworks.

97. Provision has been made for heavy Tools and Plant on all lined channels and for Headworks at 10 per cent. on the cost under I.—Works.

The 10 per cent. has been arrived at after consideration of the expenditure on the Upper Jhelum and other canals of the Triple Canal Project and the fact that it will be necessary to have far more plant on the works to be undertaken in constructing a lined channel. Rapidity of progress will be attained by having ample canal Rolling Stock to ensure the steady supply of materials independent of the provision of trucks by the North-Western Railway. There is very considerable economy in carriage of materials in using canal rolling stock which more than justifies the cost incurred in purchasing it. Unfortunately this was not realized to its full extent on the Triple Canal Project till it was too far advanced to justify the capital expenditure at that stage of the work.

II.—ESTABLISHMENT.

98. Twelve per cent. of the total of I.—Works, i.e., 11 per cent. establishment and 1 per cent. for accounts.

This figure has been arrived at in accordance with the orders of the Government of India in Circular No. 1764-A., dated 1st November 1918 taking into consideration the nature of the work to be done and the fact that no charges are exempted and that the charges for Heavy Tools and Plant are now included under I.—Works.

The figure of 12 per cent. has been maintained constant for the Lower Sirhind, Upper Sirhind and Western Jumna portions of the Project.

99. Provision is made for—

One circle consisting of the following new Divisions :—

Aliwal Headworks Division.

Ajitwal Division (Temporary), for Main Line and Grey Canal Feeder.

Phul Division (Temporary), for the Phul Feeder and Abohar Bhatinda Feeder.

Sirsa Division, for the Rori (A-9) Feeder and Rori Chautala tract Distributaries.

Bikaner Division, for the construction of the Bhatinda Bikaner Feeder and subsequently part of the Bikaner Distributaries.

Hanumangarh Division, for the construction of Bikaner Branches and subsequently part of the Bikaner Distributaries.

100. It is presumed that the channels in Bikaner State will be constructed by the Punjab Irrigation Branch, as in the case of the Phulkian State Branches and distributaries from the existing Sirhind Canal, and then handed over after 3 years' working to the State for management and maintenance.

III.—TOOLS AND PLANT (ORDINARY).

101. The provision under this head is 1½ per cent. of I.—Works. This figure is laid down in the Government of India Circular No. 1764-A., dated 1st November 1918.

IV.—SUSPENSE ACCOUNT.

102. A lump sum provision has been made for this from the analogy of similar conditions on the Triple Canal Project and the existing Sirhind Canal.

V.—RECEIPTS OF CAPITAL ACCOUNT.

103. Provision is made for 50 per cent. obtained from the sale of Railway Plant and Rolling Stock and heavy Tools and Plant only. No credit is taken for any other receipts.

INDIRECT CHARGES.

VI.—(23) CAPITALIZATION OF ABATEMENT OF LAND REVENUE.

104. This is estimated at 25 years' purchase according to P. W. D. Code, Volume II, para. 1726. The figures for land revenue have been taken in the same way as land values obtained from the Deputy Commissioners, and are given in the statement under B.—Land in paragraphs 6 and 11 above.

105. In connection with the question of capitalization of land revenue in the Phulkian States, the land for this Project will be acquired under clauses 7 and 40 of the Sirhind Canal Agreement of 1873 and heretofore no account appears to have been taken of the capitalization of land revenue of land acquired in the States. Provision over the whole area has however been made.

(25) LEAVE AND PENSION ALLOWANCES.

106. Leave and Pension allowances are provided at 14 per cent. of Establishment in accordance with para. 1726, P. W. D. Code, Volume II.

VII.—SIMPLE INTEREST.

107. Simple interest charges at 4 per cent., 5 per cent. and 5½ per cent. have been worked out for the Project as a whole on the scheme of construction expenditure estimated (see General Report, Volume I).

CHAPTER V.

Programme of Work.

1. The object aimed at in the construction of the Project as a whole, is to be able to earn revenue from the stored water as soon as it is available.

2. This leads to the Lower Sirhind Canal being pushed on the most rapidly after priority has been given to the Bhakra Dam; the amount of work that can be done depends on the establishment that will be available and the possibility of the increase in the rate of supply of material for lining.

2. Programmes for the various systems were made out and submitted to the Superintending Engineer, who finally decided that as regards the Upper Sirhind Canal it would not be desirable to attempt to start work before the third year.

3. Statement A for the Lower Sirhind Canal in the general report shows the probable yearly expenditure by main channels and distributaries during construction, this needs but little explanation.

4. Work will be started at Rampura Phul on the Phul and Rori Feeders as it will be possible to develop irrigation in the Rori Chautala tract by rotational working from the existing Bhatinda Branch, as soon as these two Feeders are completed.

5. The Phul and Rori Feeders should be completed in 4 years and the Rori Chautala Distributaries so far advanced as to enable Khurif irrigation to be started in the 5th year.

6. In the 6th year the Dam would be high enough to store a small amount of water for use in the Rabi in this tract.

7. The Abohar Bhatinda Feeder would be pushed on so as to be complete by the end of the 6th year. This would permit of both the Abohar and Bhatinda Branches being run full supply and the Rori Chautala irrigation developed by rotational working.

8. The Bhatinda Bikaner Feeder and Bikaner Branches would be completed by the 7th year and the distributaries therefrom sufficiently far advanced to permit irrigation being started in the 8th year, by which time the Headworks and Main Line of the Lower Sirhind Canal would be completed as well as the Dam which would have full storage available.

9. The alterations to the Rupar Headworks and the Main Line will be done in the 6th year, so that stored water may be utilised on the existing British Channels and the Rori Chautala tract by passing an increased discharge down the Main Line and the British Branches.

10. It is anticipated that all the Distributaries on the Lower Sirhind Canal will be completed in the 9th year, the project estimate however will not be closed until the end of the 12th year, by which time the Upper Sirhind Canal should also be complete.

CHAPTER VI.

The Grey Canals.

1. **Details of Canals.**—There are 15 of the Grey Canals so termed after Colonel Grey, Deputy Commissioner, Ferozepore, who commenced their construction in 1874. The Sutlej Dam Project is only concerned with the eight canals which take off from the river Sutlej above Ferozepore, viz., Kingwah, Aghawah, Ilahiwh, Daulatwah, Bacherowah, Barneswah, Mayawah and Butawah.

The Kingwah was the last to be constructed in 1907. The Elahiwh and Barneswah were constructed in 1897 and 1880 respectively, the remaining five were completed in 1875. Originally the Mayawah and Butawah had their heads on the Sutlej below the junction of the Beas, but now they are fed from the Barneswah, which has had its head reach enlarged to carry the increased supply required; the Elahiwh and Daulatwah are similarly fed through the Aghawah, which has been treated accordingly. There are, therefore, now only four heads from the river to these eight canals.

2. **Report of the Irrigation Commission, 1903.**—The Irrigation Commission in their report Chapter XIV, stated regarding these canals:—

Paragraph 30.—“It will not be difficult to arrange for supplying them from above the weir which would be built for the supply of the Perennial canal; an arrangement which would increase their efficiency, though it would probably involve a change in the method of their administration.”

Paragraph 58.—“Even in Ferozepore it is doubtful whether the present system can be continued indefinitely, though we hope that it will not be interfered with so long as it is efficiently worked.”

3. **Mr. Fagan's Evidence.**—In the evidence recorded before the Commission, Mr. Fagan, then Revenue Secretary to the Government, Punjab, in reply to question 5, stated:—

“My impression is that District Boards are not qualified to deal with irrigation questions. I think they could only deal with them under professional advice from the Irrigation Department. They have not means or personnel needful for running canals on approved professional lines. The Irrigation Department is the proper agency.”

4. **Colonel Grey's Evidence.**—Colonel Grey, the constructor of these canals, in his memorandum, stated:—

Paragraph 2.—“As to co-operative District Canals these may be dismissed from consideration. There is only one such enterprise that I know of which has succeeded and is of any importance and for many reasons none such is over likely to succeed again, or indeed to be attempted.”

Paragraph 3.—“Their construction is fully described in printed reports of 1875-76-77, and my painful experiences therein stated would, I imagine, deter any District Officer from attempting to imitate the operation, even were it now possible to do so. I returned to Ferozepore in 1880 to find the irrigation system in danger of collapse, but succeeded then in renewing and extending it, and I devised the existing system of maintenance before I left the District in 1882, as described in a report of that year.”

Paragraph 4.—“The method was, after all, but a makeshift; it has had its day; and the time has come for arresting the summer floods by weirs, and for distributing them scientifically over the country to afford a duty of 200 acres to the cusec instead of the 30 or 40 acres which is the average of inundation canals.”

Paragraph 5.—"In no commercial enterprise can anything be achieved unless risk is taken."

5. *Mr. Wilson's Evidence.*—Mr. J. Wilson, Settlement Commissioner, in his memorandum, stated :—

Paragraph 22.—"I am not in favour of encouraging private persons to construct further canals. Experience shows that their management is rarely satisfactory and that it is much better in the interests of the land-owners that Government should make the canals and have complete control over them. I should encourage the construction of a private canal only where I despaired of getting Government to construct it within a reasonable time, and then only on condition that Government should have full power to step in and assume the management whenever it thought proper."

6. *Sutlej Valley Project, 1911.*—Mr. Schonemann, in the Project for utilising the Sutlej Valley waters prepared by him, dated 23rd March 1911, dealt with the question of the Grey Canals, and the following is quoted from his report :—

Paragraph 58.—"Moreover a glance at the plans will show that the alignment of the existing Ferozepore canals is shockingly bad and incompatible with efficiency. They wriggle about in close proximity to each other in absolutely idiotic fashion, and cannot possibly irrigate economically or efficiently. The whole of the tract in question can best be irrigated by a system of distributaries off-taking from the Harike perennial canal or from a branch of it."

Paragraph 59.—"The alignment and formation of the Grey Canals is so defective that it will probably be hardly consistent with scientific engineering to retain or to utilise any appreciable portion of their channels under this Project. For the purposes of this preliminary report, anyhow, it will be safer to assume this, and to treat the tract commanded by these canals, on the right of the proposed alignment of the Harike Left Canal, as a *tabula rasa* for purposes of design and estimate. I have marked on Plan No. 38, in broken red lines, the alignment of a system of distributaries which may suitably supersede the Grey Canals to the right of the proposed Harike Canal alignment and I have allowed for the cost of this arrangement in my estimate."

"The Grey Canals to the left of the Harike Canal alignment will not be affected by the latter canal ; but if water can be made available for the purpose from the Sirhind Canal, it would be well to take the irrigation of this tract also on to a branch of that canal, off-taking somewhere near Jagraon. Failing that, the whole of the Grey Canals tract to the left of the proposed Harike Canal may best be irrigated by a single inundation canal flowing along the well-defined ridge that lies between the two Ferozepore-Ludhiana Roads."

Attached as appendices are copies of—

Letter No. 741 of 16th February 1911 from the Deputy Commissioner, Ferozepore. (Appendix D 7.)

Note by Mr. Herdon, Superintendent, Grey Canals, dated 7th February 1911. (Appendix D 7.)

Note by Mr. Currie, Settlement Officer, Ferozepore, dated 13th February 1911. (Appendix D 8.)

7. **Mr. Currie's Report.**—The special report by Mr. Currie, Settlement Officer, Ferozepore, dated 8th November 1913, deals at length with the history and condition of the canals at the time of settlement, it is printed up with reviews on it as proceedings No. 8-42, April 1916, File 13 R & A.

Some of the more pertinent paragraphs are attached as (Appendix D 8).

8. **Mr. Fagan's opinion, 1914.**—Mr. Fagan, Commissioner, Jullundur Division, in his review of Mr. Currie's report expressed himself as follows:—

"Though the system has undoubtedly been productive of considerable economic benefit, more especially in its earlier stages, it has had to pay the usual penalty for an unscientific alignment of main channels, namely, excessive silting and damage to soil arising from want of control over excess supplies when such enter the canals."

"But on the whole Mr. Currie's conclusion that the canals are in a very unsatisfactory condition must I fear be accepted, while the view given in Chapter III of the report (paragraphs 15 to 18 in Appendix D) of the present general condition of the tract served by them is I think an accurate one."

"Mr. Currie gives solid reasons against the suggestion which has been made that the Government should acquire the canals and manage them through the agency of the Irrigation Department. They are many and weighty and the idea may I think be dismissed without further discussion here."

"It is abundantly clear that if the canals are to be improved or indeed even pay their way, more income must be obtained, and for this object an immediate moderate enhancement of the *abianx* is clearly not only defensible but eminently desirable."

9. **The Zamindars' opinion.**—The opinion of the Zamindars themselves regarding the canals is best shown by the copy of one of the petitions received (Appendix D 9). It will be seen that they desire a supply of water and are imbued with the co-operative spirit in its broadest sense in desiring to get a better supply for irrigation at the Sirhind Canal rates to the benefit of themselves and Government.

The Deputy Commissioner, Ferozepore, in his No. 861, dated 31st May 1882, informed the Superintending Engineer, Sirhind Canal, that from enquiries made from 25 villages, 23 villages were prepared to take water from the Sirhind Canal and pay the full water rates.

10. **Opinion of the Superintendent, Grey Canals.**—The opinion of the Superintendent, Grey Canals, regarding the eight canals affected by the Sutlej Dam Project is given in his No. 270 of 22nd November 1916. (Appendix D 10).

11. **General opinion.**—The writer has hesitated to give his opinion on the existing state of the Grey Canals and the tract effected thereby; but it is believed that the above will convince anyone of the unsatisfactory state of affairs that exists; doubtless Government has recently sanctioned a considerable annual grant for 5 years, about 2½ lacs in all, to improve the canals, but when they were built admittedly as a makeshift, on fundamentally unsound lines from an engineering point of view, nothing will put matters right except a radical scrapping of all the channels which run in the drainages and the substitution of branches and distributaries on the ridges leaving the present channels in the drainages to act as such.

12. **Drainages blocked.**—Late in the year 1918 the Local Government constituted a Drainage Board to deal with the question of water-logging and obstructed drainages. On the Upper Bari Doab Canal a special Drainage Division has been formed to remedy the evil of blocked drainages in that tract and it would appear that a similar policy is required in this tract.

13. **Malaria.**—A reference to the Reports on Malaria in the Punjab, 1914 and 1915, will shew that the spleen index of children in the schools in 1914 was 66·5% at Jalalabad in the Grey Canal tract and 15·9% for the whole District of Ferozepore, a great portion of which is in the high bar land. In the Amritsar District 43·4% was the highest individual figure and 10·3% the figure for the whole District.

14. **The change of administration.**—The tenour of all that has been written is that a change in administration would not be acceptable to the Zamindars, that the canals belong to the Zamindars and that Government should not interfere with their rights, but the conditions under which permission was given to construct the canals appears to have been lost sight of and a reference should be made to the orders of Government in Secretary, Civil Department's No. 1411 of 4th October 1875.

A translation of the original agreement signed by the Zamindars of each village when the canals were constructed is attached (Appendix D 11). Paragraph 15 clearly and specifically lays down that they shall have no cause for complaint if Government stops irrigation. Paras. 19 and 20 give Government full power to carry out its wishes and the Zamindars place themselves entirely at Government's pleasure in dealing with the canals.

Doubtless the canals themselves as they exist are the property of the Zamindars, no one would deny this, but the water is the property of the Supreme Government and little if any weight appears to have been given to the fact that the Zamindars have enjoyed the free use of the water, only having had to incur the labour and expenditure involved in getting the water on to the fields. Their land revenue has been increased as is the case when irrigation is done from wells. Compensation is not paid to Zamindars for wells thrown out of use by the introduction of canal irrigation.

It is worthy of note that these canals were constructed after the Canal Act VIII of 1873 had been passed which enacted that the whole of the waters of the Punjab rivers were vested in the Government.

There appears no legal or equitable reason why Government should not construct a scientifically sound canal and series of distributaries through the tract as it does elsewhere and charge the normal water-rates as levied on the Charif channels of the Sirhind Canal.

If it was found that any lengths of existing channels could be utilised, and they would be very few, probably only the smaller channels, the land in which they ran would be acquired, but it would be practically impossible to pay compensation for the earthwork, etc., of the channel as there would be no reasonable method of determining the persons entitled to compensation and their share in it.

If, when the Government had completed the system, it felt that the Zamindars should have been compensated, had it been possible, as an act of grace, it could benefit the Zamindars of the tract by making a grant to construct pacca roads in the area or giving some such similar material benefit, which all would enjoy.

If Government were to replace the existing canals and introduce a drainage scheme, it is probable that greater lengths of channels would be taken up as drains than for irrigating channels.

15. **Proposals under the Sutlej Dam Project.**—In view of the acceptance by Government of the opinions expressed of the undesirability of interfering, the Sutlej Dam Project only provides for the most economical feeder channel from the Lower Sirhind Canal Main Line, which will connect up and supply the head reaches of the existing canals, so as to prevent their being affected by further abstraction of water from the Sutlej. The Zamindars have no legal claim according to their agreement but the arrangement is made to prevent economic loss.

Appendix D-1 gives the Hydraulic data of the head reaches of the canals.

Appendix D-2 gives the dates of opening and closing the canals for the 10 years 1906-1916.

Appendix D-3 gives an abstract of the earliest and latest dates of opening and closing of the canals.

16. *Dates of opening and closing of the canals.*—It will be noted that the mean dates of the first and last canals to open are the 15th of May and the 6th June respectively. The mean date of the canals opening taken as a whole is 25th May.

The discharge at Bhakra two days before the opening of the canals is given in cusecs. It is not understood why the opening was so late in the year 1915-16 with such a high discharge in the river.

The figures for the three years 1912-14 appear to be very concordant giving an average of 16,000 cusecs which is near the discharge of 19,000 cusecs, the average of the last 6 years at Bhakra on May 25th, the mean date of opening.

The mean dates of the first and last canals closing is September 8th and 4th October respectively. The mean date of the canals closing taken as a whole is 21st September when the average discharge at Bhakra for the last 6 years is 22,000 cusecs. These canals have not on the average been able to get a supply before the supply at Bhakra rose to 19,000 cusecs, or after it fell below 22,000 cusecs. It will be noted that a larger supply is required in the autumn to run the canals as their beds are then silted.

17. *Working of the canals when supplied from above a weir.*—With a weir across the river the Lower Sirhind Canal will be able to pass water into the Grey Canal system, through the proposed Grey Canal Feeder, as soon as any supply is surplus above the requirements of the perennial channels of the whole Sirhind system. The total capacity of the whole system including the Grey Canals is 19,759 cusecs which is about the amount which when running in the river can only just run these canals as inundation canals with a low supply.

There will, therefore, be no difficulty about the rights of the Grey canal irrigators being interfered with by the construction of the Sutlej Dam Project so far as the dates of commencement and cessation of flow are concerned.

The condition as to their supply will be, that so long as or as soon as the normal flow of the river apart from storage is less than the demand for the perennial channels of the Upper and Lower Sirhind system, no water will be available for use in the Grey Canal Feeder.

The demand in the system at the time of opening will be much less than its full capacity and the Grey Canals will materially benefit in being able to get an earlier and assured supply.

18. *Areas irrigated.*—The details regarding the maximum and minimum area of irrigation performed by the whole of the Grey Canals in the 10 years period 1899—1910 are extracted from Mr. Currie's report and given in Appendix D-4.

It has been found that there were discrepancies in the figures in the statements in Mr. Currie's report, but what is noticeable is the enormous fluctuation in irrigated area between the minimum year 1910-11, 97,201 acres and the maximum year 1906-07, 270,340 acres.

Since he wrote his report the statistics and returns of irrigation have been more reliable as they have been maintained on lines laid down by him. The figures for the eight canals effected by this Project have been obtained from the Grey Canal Office, and the corresponding figures for the 5 year period available, have been added under those of Mr. Currie for the ten year period, in Appendix D-4.

19. **Duties.**—The annual full supply factor at the canal heads has been worked out and it shews the wonderfully low figure of 23 and 36 acres of irrigation per cusec of capacity or full supply in the worst and best years respectively! There is no record of discharges utilised so that it is impossible to estimate the actual duty on the water used.

The original figures of areas irrigated by the canals in both crops obtained from the Grey Canals Office and abstracted are given in Appendices D-5 and 6.

The average areas sown on the eight canals affected by the project are—

Kharif 35,701 acres and Rabi 23,274 acres. Total 58,975 acres, 83·2 per cent. of the crops sown being matured. The full supply factor for the area of both crops is 27·4 acres per cusec capacity or lower than the lowest figure quoted by Colonel Grey to the Irrigation Commission.

20. **Supply now to be provided.**—The working of the canals being so irregular, it will be unnecessary to provide for a supply from the Lower Sirhind Canal equal to their reputed full supply of 2,148 cusecs. A capacity of 1,000 cusecs has been provided for in the Main Line lower for the Grey Canal Feeder. The Feeder itself has been designed to carry that supply and permit of a 50 per cent. excess being passed down when required and available. It is very seldom that the Main Line of a canal runs absolutely full supply and it costs little more to make the Feeder carry an extra supply, whereas to increase the capacity of the Main Line would be very costly as it is a lined channel.

21. **Alignment of the Feeder.**—The Feeder will take off the tail of the Main Line Upper at the Sidhwan-Jagraon Road crossing near Sidhwan, and thence run straight to the Kingwah Canal, which it will meet about mile 3½. The Kingwah will be enlarged from mile 3½ to mile 7, where the Feeder leaves its alignment and joins the Aghawah at mile 4 above the regulator. From this point onwards the Feeder will follow the alignment of the lower canals, escapes and old arms of the river, until at 36 miles from the Head at Sidhwan, it reaches the head of the Mayawah.

22. **Estimated costs.**—The construction of the Feeder presents no difficulties. The cost of acquiring the land occupied by the new reaches and the old lengths utilised in linking up their head reaches has been provided for.

The total estimated cost is—

	Rs
Cost of Feeder direct and indirect	12,35,931
Share of the cost of the Main Line	4,73,000
Ditto Headworks	8,31,000
Making a total cost of	25,40,231

Of the amount Rs. 12,35,931, Rs. 9,90,172 is for I.—Works. For this expenditure the canals will get an assured supply of 1,000 cusecs.

23. **Irrigation provided.**—The irrigation provided for is 1,000 cusecs x 70 full supply factor = 70,000 acres, against a mean total of 58,000 acres sown for the last five years. See Appendix D 5.

Note.—The Kharif Irrigation on the Sirhind Canal Kharif Distributaries allowed for in remodelling is 16·6 per cent with a full supply factor of 70. This would in the case of these canals with 425,000 acres gross area within irrigation limits give a Kharif area of $\frac{425,000 \times 16.6}{100} = 70,633$ say 70,000 acres. No consideration is given to the Rabi waterings which with a controlled supply would amount to as much as the Kharif area.

This 58,000 acres is the total area irrigated on all the eight canals. The tails of some of these canals pass under the Sutlej Navigation Channel of the existing Sirhind Canal and the irrigation below this Channel will be cut off from these canals and supplied from distributaries to be constructed, from the Sutlej Navigation Channel, to take up the irrigation south-west of that channel. The area of irrigation thus cut off is small.

24. **Revenue.**—The revenue to be realised per acre irrigated according to Financial Commissioner's Note, dated 24th November 1917, will be Direct Rs. 1.25, Indirect .75, Total Rs. 2.

Working expenses are taken to be Re. 1 per acre as for the rest of the Project.

The net profit will be Re. 1 per acre or Rs. 70,000 on the capital sunk of Rs. 25,40,231 or 2.76 per cent., making it an unproductive work.

25. **Benefits.**—The irrigators will benefit in that they will get a much more regular supply of water and over the whole period of flow probably a greater quantity of water, but the inefficiency of the distribution system will not be improved and the trouble of water-logging and increase of kallar will still continue as at present.

This arrangement for supplying the Grey Canals from above a weir is the most suitable and economical that can be made without interfering with the existing canals. Any further improvement would necessitate abandoning the whole system as it exists at present.

26. **Future hopes.**—It may be that before the Project is carried into effect, that a statesmanlike view will be taken of the case and it will be decided to do the best that can be done for the tract by replacing the proposed Feeder by a branch, which after meeting the Kingwah Canal, will follow its alignment to near Jalalabad and then follow the ridge of the country to near Zira, throwing off distributaries along suitable alignments, without regard to existing channels.

This will distribute the irrigation equally over the whole tract, as complete command is obtained. The unsatisfactory condition which exists now of the low-lying villages getting an abnormally high intensity of irrigation and high villages little or nothing, will be removed.

In the folio of plans of the Lower Sirhind Canal is a 1 inch to 1 mile tracing which shows by distinctive colouring the intensity of irrigation in each village. A glance at this plan at once makes the present unequal distribution of irrigation evident.

The total length of channel required in the tract would be very much lessened and the increase in cost over the scheme for this tract as estimated would not be so very great, as in place of the Feeder 36 miles long, a branch of slightly less length would be required with the necessary distributaries. The shorter branch on the ridge would go through more valuable land and require more bridges, and not have the benefit of utilising existing channels in certain reaches, so that the cost of the two may be assumed to be the same.

The extra cost involved would then only be that of distributaries. The gross area North of the Sutlej Navigation Channel is 425,000 acres and assuming that the cost of distributaries would be Rs. 3 per acre gross as elsewhere in the Project.

The extra cost for works would be $\text{Rs. } 4,25,000 \times 3 = \text{Rs. } 12,75,000$. The total extra cost Direct and Indirect by proportion from the figures of the Feeder as estimated would be :—

$$12,75,000 \times \frac{12,35,931}{9,90,172} = \text{Rs. } 15,91,453.$$

The total cost would then be :—

$$\text{Rs. } 25,40,231 + 15,91,453 = \text{Rs. } 41,31,684.$$

This would give the most perfect scheme possible in accordance with the present state of irrigation science.

The actual area irrigated and revenue to be obtained can be taken from the analogy of the Sirhind Canal Kharif distributaries and can therefore be estimated to a nicety.

The full supply factor of the Sirhind Canal Kharif distributaries which irrigate in a tract of similar rainfall is 42 acres Kharif, 56 acres Rabi first.

watering, and this would give 42,000 acres Kharif and 56,000 acres Rabi irrigation. Total 98,000 acres on a gross area of 425,000 or an intensity of 23 per cent. assuming that the full supply was restricted to 1,000 cusecs.

The direct revenue that would be received according to the figures in the Chief Engineer's No. 127-R. I., dated 5th February 1918, would be :—

			Rs.
Kharif	...	...	42,000 × 4'8 = 2,01,600
Rabi	...	...	56,000 × 1'6 = 89,600
			<hr/> 2,91,200

The indirect revenue at 75 per acre would be :—

	98,000 × 75 =	73,500
		<hr/>
Gross Revenue	...	3,64,700
Deduct.—Working expenses 98,000 acres at Re. 1 per acre	...	98,000
		<hr/>
Net revenue	...	2,66,700

The return on the capital cost would be—

$$\frac{2,66,700}{41,31,684} = 6'45 \text{ per cent.}$$

This scheme, although involving a greater capital cost, would also give financial return which would bring it into the class of Productive works.

The condition of the tract would not only improve but be saved from further deterioration, and the health and welfare of the inhabitants would be materially benefited.

H. W. NICHOLSON,

B.Sc., A.M.I.C.E.,

Executive Engineer, Project Division,

Sirhind Canal.

SUTLEJ DAM PROJECT.

— — — — —
LOWER SIRHIND CANAL.

— — — — —
ESTIMATE.

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

ABSTRACT OF COST OF ALI WAL HEADWORKS.

A.—DIRECT CHARGES.						Rs.
I.—Works.—						
1.—Headworks.—						
A.—Preliminary	...	...	...	...	...	87,000
B.—Land	...	...	...	...	...	11,20,207
C.—Works.—						
Training Works	...	...	...	...	11,55,744	
Weir and Sluices	...	...	...	...	27,81,143	39,36,887
K.—Buildings	...	...	...	...	...	2,19,000
M.—Plantations	...	...	...	...	...	75,000
O.—Miscellaneous	...	...	...	...	...	67,920
P.—Maintenance	...	...	...	...	...	1,25,000
Q.—Losses on Stock	...	...	...	...	...	20,000
Total I.—Works (Headworks)						56,51,114
5. Special Tools and Plant (heavy)	...	...	...	...	...	13,90,111
Total I.—Works						70,41,225
II.—Establishment, 12 per cent.	...	...	...	...	...	8,44,947
III.—Tools and Plant (ordinary), 1½ per cent.	...	...	...	...	...	1,05,618
IV.—Suspense Account	...	...	...	...	...	2,00,000
V.—Receipts on Capital Account	...	...	...	...	...	6,95,056
Total A.—Direct Charges						74,96,734
B.—INDIRECT CHARGES.						
VI.—(23) Capitalization of abatement of Land Revenue	...	...	...	...	...	75,675
(25) Leave and Pension Allowance 14 per cent. of Establishment	...	...	...	...	...	1,18,293
Total B.—Indirect Charges						1,93,968
Total Direct and Indirect Charges						76,90,702
VII.—Simple Interest charges during construction						...
Dealt with for the Project as a whole in the General Report, Volume I.						...

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

HEADWORKS.

A.—PRELIMINARY.

	Amount.	Total.
	Rs.	Rs.
Share of the cost of preparation of the original Project	12,000	
Further surveys prior to construction and laying out work...	15,000	
Miscellaneous discharges and investigations	5,000	
Laying out Station Roads, etc.	5,000	
Inauguration ceremony	50,000	
GRAND TOTAL A.—PRELIMINARY ... ..	...	87,000

HEADWORKS.

B.—LAND.

	Amount.	Total.
	Rs.	Rs.
<i>Ludhiana and Jullundur Districts.</i>		
Chahi land, 60 acres, @ Rs. 437 per acre	26,220	
Barani land, 2,482 acres, @ Rs. 180 " "	4,46,760	
Jungle and River bed, 4,952 acres, @ Rs. 100 per acre	4,95,200	9,68,180
Land for Superintending Engineer's Office and Bungalow, probably at Ferozepore, lump sum	4,000	
Land for Executive Engineer's Office and Bungalow at Ludhiana, lump sum ..	2,000	6,000
Compulsory acquisition @ Rs. 15 per cent. on Rs. 9,74,180	1,46,127	1,46,127
GRAND TOTAL B.—LAND ... ..	...	11,20,307

HEADWORKS.

RIVER TRAINING WORKS.							Amount.	Total.
(AS DETAILED ESTIMATES.)							Rs.	Rs.
UPSTREAM LEFT MARGINAL BUND—								
Regulator for Budha Nala Diversion	29,667		
Earthwork of Budha Nala Diversion	1,26,861		
Marginal Bund	2,37,825	3,94,353	
UPSTREAM LEFT GUIDE BANK							...	2,29,490
UPSTREAM RIGHT SPUR							...	1,12,762
UPSTREAM RIGHT GUIDE BANK							...	79,296
UPSTREAM RIGHT FLANK EMBANKMENT							...	29,898
DOWNSTREAM GUIDE BANKS—								
Left	61,221		
Right	61,221	1,22,442	
DOWNSTREAM SPURS—								
Right Spur	53,852		
Left Spur	53,852		
Shank of Right Spur	40,744		
Shank of Left Spur	7,484	1,55,932	
DOWNSTREAM LEFT MARGINAL BUND							...	31,001
TOTAL RIVER TRAINING WORKS							...	11,55,774

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

HEADWORKS.

C.—WORKS.

WEIR AND UNDERSLUICES.						Rs.
(AS DETAILED ESTIMATES.)						
Undersluices, Left Flank and half Bay ...	...	...	...	...	...	61,938
Undersluices, seven Bays and seven Piers ...	...	...	...	...	...	1,44,186
Weir Right Flank and half Bay ...	...	...	...	...	...	99,369
Weir 26 Bays ...	...	...	...	...	...	8,17,310
Extra for 2 No. 12' Piers and Divide Walls ...	...	...	...	...	...	22,420
Extra for 3 No. 12' Piers without Divide Wall ...	...	...	...	...	...	14,650
Left Flank Divide Wall, Fish Ladder and Pocket Floor with Half Spans of Undersluices and Weir ...	...	...	...	...	...	3,56,984
Right Flank Divide Wall and Fish Ladder with two Half Spans of Weir ...	...	...	...	...	...	1,00,062
Extra Protection to four Right Flank Bays of Weir Downstream ...	...	...	...	...	...	8,424
Gates and Gearing 21,120 s. ft. ...	...	...	...	...	...	8,44,800
Road Bridge Rs. 2,76,480 ...	...	...	...	...	...	not included
Pumping ...	...	...	...	...	...	1,00,000
Earthwork (above Pacca Work over whole Weir and Undersluices) ...	...	...	...	...	...	70,000
Ring Bunds and River Diversion Works... ...	...	...	...	...	...	50,000
Unforeseen including Damage by Floods ...	...	...	...	...	...	1,00,000
TOTAL WEIR AND UNDERSLUICES ...						27,81,143

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

HEADWORKS.

K.—BUILDINGS

Total cost of Permanent Buildings	...	...	...	...	...	Rs. 1,92,000
Total cost of Temporary Buildings	...	..	...	...	...	27,000
Note.—As statement for the whole Lower Sirhind Canal under K.—Buildings.						
Total					...	2,19,000

HEADWORKS.

M.—PLANTATION.

Avenue 25 miles, at Rs. 100 a mile	...	...	..	...	...	Rs. 2,500
12½ miles Up and Downstream Bunds.						
Plantation 2,500 acres, at Rs. 25 per acre	...	...	...	...	...	62,500
Station Site, lump sum	...	...	...	...	..	10,000
Total					...	75,000

HEADWORKS.

O.—MISCELLANEOUS.

Boundary pillars, 36 miles, at every 500 feet and 10 per cent. for curves at Rs. 6 each, per mile Rs. 120.						Rs. 4,320
Distance marks, 16 miles, at every 1,000 feet, Rs. 20 each, per mile Rs. 100	...	...	...	...	...	1,600
Drainage of bunds, 16 miles, at every 1,000 feet 80 Nos. at Rs. 120 each	...	...	...	...	...	9,600
Bench Marks, 8 Nos. at Rs. 50 each	...	...	...	...	...	400
Fencing Canal Station	...	...	...	...	...	15,000
Experiments	...	...	...	...	...	15,000
Conservancy	...	...	...	...	...	12,000
Unforeseen	...	...	...	...	...	10,000
Total					...	67,920

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

HEADWORKS.

P.—MAINTENANCE.

In the Revised Project for the Upper Chenab Canal, the provision for Maintenance on Headworks was 1·8 per cent. of the total of C. Works and K. Buildings. For the Lower Bari Doab, the provision was 2·3 per cent. of the same heads.	Rs.
The provision for C. Works and K. Buildings for these Headworks is 41½ lakhs 2·5 per cent. of which is Rs. 1,03,750.	
Provision made, say	1,25,000

HEADWORKS.

Q.—LOSSES ON STOCK.

Losses on Stock—Lump sum	Rs. 20,000
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HEADWORKS.

I. 5.—SPECIAL TOOLS AND PLANT.

RAILWAYS.	Amount.	Total.
<i>Ajitwal to Headworks, 21 miles.—</i>	Rs.	Rs.
Cost of connection at Ajitwal Station—Lump sum	8,000	
Permanent-way 21 miles laid at Rs. 30,000 per mile	6,30,000	
Bridge over Budha Nala, 30 feet water-way, at Rs. 400 per foot ...	12,000	
This Railway will be required permanently as in the case of all other Headworks, if handed over to Railway Company or worked as a Branch Line the credit to Capital Account would be $21 \times 20,000 = 4,20,000$ Rupees. Share of cost of Railway Line to Nalagarh Quarries from Ghanauli. Total cost 10 miles at Rs. 30,000 per mile = Rs. 3,00,000 debited to this head Rs. 1,75,000.	1,75,000	8,25,000
The balance Rs. 1,25,000 goes to the Upper Sirhind Canal, Pattiala-Kaithal Feeder.		
<i>Special Tools and Plant (heavy).</i>		
The provision for special Tools and Plant (heavy) is made at the rate of 10 per cent. of total I.—Works, Headworks, Rs. 56,51,114		5,65,111
Total I. 5.—Special Tools and Plant		13,90,111

HEADWORKS.

II.—ESTABLISHMENT.

The provision of Establishment is made at the rate of 12 per cent. of total I.—Works, Rs. 70,41,225.	Rs. 8,44,947
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SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

HEADWORKS.

III.—TOOLS AND PLANT (ORDINARY).

	Rs.
The provision for III.—Tools and Plant is made at the rate of $1\frac{1}{2}$ per cent of total I.—Works, Rs. 70,41,225.	1,05,618

HEADWORKS.

IV.—SUSPENSE ACCOUNT.

	Rs.
This figure is fixed from consideration of suspense on the Rupar Headworks at ...	2,00,000

HEADWORKS.

V.—RECEIPTS ON CAPITAL ACCOUNT.

	Rs.
A credit on account of Receipts on Capital Account is made at the rate of 50 per cent. of 1. (5) Special Tools and Plant, Rs. 13,90,111	6,95,056

HEADWORKS

VI.—(23) CAPITALIZATION OF ABATEMENT OF LAND REVENUE.

<i>Ludhiana District.</i>	Amount. Rs.	Total. Rs.
Chulhi land, 60 acres at Re. 1-5-5 per acre	80	
Barani land, 2,482 acres at Re. 1-1-0 per acre	2,687	
Jungle land, 4,052 acres at Re. 0-1-0 per acre	810	
Annual Revenue Total ...	3,027	
Note.—Capitalization of Land Revenue 25 years' purchase, P. W. D. Code, Volume II, para, 1726.		
Capitalized 25 × 3,027 ... ..	...	75,675

HEADWORKS.

VI.—(25) LEAVE AND PENSION ALLOWANCE.

	Rs.
The provision for VI (25) Leave and Pension Allowance is made at the rate of 14 per cent. of Establishment, Rs. 8,44,947.	1,18,298

SUTLEJ DAM**LOWER SIRHIND****ABSTRACT OF COST OF MAIN LINE**

HEAD OF CLASSIFICATION.	Main Line Upper.	Grey Canals.	Main Line Lower.	Abohar Branch Irrigation.	Abohar- Bhatinda Feeder.	Phul Feeder.
1	2	3	4	5	6	7
A.—DIRECT CHARGES.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
I—(2) Main Canal and Branches—						
A.—Preliminary	3,250	14,000	10,625	..	10,250	2,550
B.—Land	1,52,669	3,69,675	6,20,166	...	6,00,082	1,17,519
D.—Regulators	4,27,764	42,163	1,35,701	..	1,02,598	61,813
E.—Falls and Weirs ... ..	...	57,000	...	...	..	..
F.—River and Hill Torrent Works	96,176	...	22,470	..	17,800	...
F. 1.—Other Cross Drainage Works ... ..	...	...	..	...	...	...
G.—Bridges	1,30,368	1,11,805	3,60,909	..	2,73,452	68,570
G. 1.—Canal Crossings ... ..	...	...	31,608	...	1,12,280	75,016
H.—Escapes ... ..	..	...	...	...	...	...
J.—Mills ... ..	...	...	...	..	...	...
K.—Buildings ... ..	...	...	69,250	...	58,000	1,33,750
L.—Earthwork	7,79,616	2,74,509	23,94,803	...	10,47,947	1,60,678
L. 1.—Lining	18,92,000	...	36,47,200	...	35,05,000	7,01,640
M.—Plantation	8,900	6,100	30,025	...	17,300	6,875
N.—Tanks and Reservoirs ... ..	...	...	...	...	...	...
O.—Miscellaneous	23,430	34,020	57,670	...	69,000	18,454
P.—Maintenance	45,000	75,000	97,500	...	1,05,000	37,500
Q.—Losses on Stock	4,000	6,000	8,000	...	8,000	3,000
Total Main Canal and Branches	35,64,163	9,90,172	74,85,818	...	59,26,509	14,08,565
(3) Distributaries ... ..	...	...	...	2,80,000	...	...
(4) Drainage and Protection Works ... ..	...	...	...	...	..	...
(5) Special Tools and Plant	3,56,416	..	9,96,552	...	13,42,651	3,58,856
Total of I.—Works	39,20,579	9,90,172	81,82,400	2,80,000	72,69,160	17,67,421
II—Establishment, 12 per cent.	4,70,469	1,18,821	10,17,858	33,800	8,72,299	2,12,690
III—Tools and Plant (ordinary), 1½ per cent.	58,809	14,653	1,27,238	4,200	1,09,037	28,511
IV—Suspense Account	10,000	20,000	20,000	10,000	20,000	5,000
Total	44,59,857	11,43,846	93,47,524	3,27,800	82,70,496	20,11,022
V—Receipts on Capital Account	—1,78,208	...	—1,98,291	...	—6,71,326	—1,79,428
Total A.—Direct Charges	42,81,649	11,43,846	91,49,233	3,27,800	75,99,170	18,31,594
B.—INDIRECT CHARGES.						
VI—(23) Capitalization of Abatement of Land Revenue.	24,775	75,450	66,950	...	44,875	7,500
(25) Leave and Pension Allowance, 14 per cent.	65,866	16,635	1,42,504	4,704	1,22,122	29,693
Total B.—Indirect Charges	90,641	92,085	2,09,454	4,704	1,67,997	37,193
Total Direct and Indirect Charges	43,72,290	12,35,931	93,58,687	3,32,504	77,65,967	18,68,787
VII—Simple Interest during Construction						

Dealt with for the Project as a whole

CANAL.

BRANCHES AND DISTRIBUTARIES.

Robri (A-9) Feeder.	Robri Chataula (A-9) Distributaries.	Bhatinda- Bikaner Feeder.	Bikaner Branches.	Bikaner Distributaries.	Abohar Branch Alterations.	Bhatinda Branch Alterations.	Total of Lower Sirhind Canal System.	Item.
8	9	10	11	12	13	14	15	16
Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	
14,600	...	14,500	16,450	..	..	...	88,225	A
3,62,648	...	6,31,810	62,352	...	...	...	29,27,621	B
61,535	...	88,616	96,845	...	82,347	83,700	10,08,238	D
...	..	55,513	24,053	..	4,000	5,000	1,46,166	
...	...	...	29,700	...	..	...	1,65,848	
...	...	...	...	..	...	...	...	F. 1.
2,56,580	...	3,13,203	1,65,200	...	6,000	13,600	17,10,775	G
1,11,890	...	8,366	...	...	11,46,452	57,156	15,43,670	G. 1.
...	...	...	...	...	...	...	...	H
20,000	...	60,000	30,000	...	...	...	1,10,000	J
5,20,250	...	1,54,000	5,58,750	...	...	...	17,94,000	K
4,77,470	...	8,44,705	5,34,896	...	52,634	20,570	66,17,628	L
20,98,080	...	35,75,850	27,15,040	...	...	...	1,81,35,040	L, 1.
28,950	...	23,275	37,400	...	..	...	1,58,825	M
...	...	...	...	...	...	...	...	N
60,418	...	79,470	51,946	...	...	...	4,08,408	O
90,000	...	90,000	60,000	...	...	..	6,00,000	P
8,000	...	8,000	5,000	...	...	...	50,000	Q
41,08,521	...	58,97,235	47,08,232	..	13,31,633	1,88,291	8,55,55,142	
...	20,43,000	..	...	27,63,750	...	...	50,56,750	(3)
...	...	...	...	...	...	...	...	(4)
14,54,952	...	11,20,223	7,38,323	...	...	...	68,68,003	(5)
55,61,473	20,43,000	70,17,458	54,48,555	27,63,750	13,31,633	1,88,291	4,70,09,895	
6,67,737	2,45,167	8,42,095	6,52,587	3,31,650	1,69,796	15,035	56,41,187	II
83,487	30,645	1,05,262	81,898	41,456	19,975	1,910	7,05,148	III
20,000	80,000	15,000	20,000	60,000	...	...	3,60,000	IV
68,35,677	23,98,805	73,73,815	62,01,849	32,16,853	15,11,401	1,51,285	5,38,56,280	
-7,27,476	..	-5,40,111	-3,69,161	...	..	..	-31,84,001	V
56,08,201	23,98,895	71,19,701	58,32,519	32,16,853	15,11,401	1,51,288	5,01,72,229	
21,425	...	32,850	20,975	...	...	...	2,91,600	VI (23)
93,463	34,322	1,17,803	91,502	46,431	22,372	2,239	7,69,766	(25)
1,14,949	31,322	1,50,743	1,12,477	44,431	22,372	2,239	10,84,966	
57,23,103	24,33,127	76,70,447	69,45,156	32,63,287	15,33,776	1,53,527	5,15,56,595	

in the General Report Volume, I.

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

2.—MAIN CANAL AND BRANCHES.

A.—PRELIMINARY.

MAIN LINE UPPER.			Amount. Rs.	Total. Rs.
Share of cost of preparation of the original Project	...	...	1,000	3,250
Surveying and Lining out 9 miles at Rs. 100 per mile	...	...	900	
Clearing Boundary Roads 9 " Rs. 150 "	...	...	1,350	
MAIN LINE LOWER.				
Share of cost of preparation of the original Project	...	...	6,000	10,625
Surveying and Lining out 18½ miles at Rs. 100 per mile	...	...	1,850	
Clearing Boundary Roads 18½ " Rs. 150 "	...	...	2,775	
GREY CANALS FEEDER.				
Share of cost of preparation of the original Project	...	...	Nil	14,000
Further Surveys prior to construction Lump sum	...	...	5,000	
Surveying and Lining out 36 miles at Rs. 100 per mile	...	...	3,600	
Clearing Boundary Roads 36 " Rs. 150 "	...	...	5,400	
ABOHAR-BHA'TINDA FEEDER.				
Share of cost of preparation of the original Project	...	...	4,000	10,250
Surveying and Lining out 25 miles at Rs. 100 per mile	...	...	2,500	
Clearing Boundary Roads 25 " Rs. 150 "	...	...	3,750	
PHUL FEEDER.				
Share of cost of preparation of the original Project	...	...	1,000	2,550
Surveying and Lining out 6·2 miles at Rs. 100 per mile	...	...	620	
Clearing Boundary Roads 6·2 " Rs. 150 "	...	...	930	
RORI (A-9) FEEDER.				
Share of cost of preparation of the original Project	...	...	6,000	14,600
Surveying and Lining out 34·4 miles at Rs. 100 per mile	...	...	3,440	
Clearing Boundary Roads 34·4 " Rs. 150 "	...	...	5,160	
BIKANER-BHATINDA FEEDER.				
Share of cost of preparation of the original Project	...	...	3,000	14,500
Surveying and Lining out 46 miles at Rs. 100 per mile	...	...	4,600	
Clearing Boundary Roads 46 " Rs. 150 "	...	...	6,900	
BIKANER BRANCHES.				
Share of cost of preparation of the original Project	...	...	1,000	16,450
Surveying and Lining out 61·8 miles at Rs. 100 per mile	...	...	6,180	
Clearing Boundary Roads 61·8 " Rs. 150 "	...	...	9,270	
NOTE.—Main Branch	...	53·0 miles.		
Border Branch	...	8·5 "		
Total	...	61·8 "		
GRAND TOTAL A.—PRELIMINARY			...	86,225

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

2.—MAIN CANAL AND BRANCHES.

B.—LAND.

MAIN LINE UPPER.				Amount. Rs.	Total. Rs.
<i>Ludhiana District.</i> —					
From mile 2 to 8—4,000 feet.					
Chahi land, 25 acres, at Rs. 575 per acre	...	...	...	14,375	
Barani " 530 " at Rs. 225 " " ...	...	...	...	1,19,250	
		Total	...	1,33,625	
Compulsory acquisition at 15 per cent.	...	...	...	20,044	1,53,669
NOTE.—Land above mile 2 is included in that for headworks.					
GREY CANAL FEEDER.					
<i>Ludhiana District.</i> —					
Barani land, 241 acres, at Rs. 225 per acre	...	...	...	54,225	
<i>Ferozepore District.</i> —					
Chahi land, 234 acres, at Rs. 450 per acre	...	...	...	1,05,300	
Barani " 830 " at Rs. 195 " " ...	...	...	...	1,61,850	
		Total	...	3,21,370	
Compulsory acquisition at Rs. 15 per cent.	...	...	...	48,205	3,69,575
NOTE.—Rate for <i>Ferozepore Bet</i> is taken the same as for <i>Jagraon Bet</i> .					
MAIN LINE LOWER.					
<i>Ludhiana District.</i> —					
From mile 8—4,000 feet to 18—2,500 feet.					
Chahi land, 30 acres, at Rs. 575 per acre	...	...	...	17,250	
Barani " 821 " at Rs. 225 " " ...	...	...	...	1,84,725	
<i>Ferozepore District.</i> —					
From mile 18—2,500 feet to 27—3,000 feet.					
Nahri land, 189 acres at Rs. 500 per acre	...	...	...	94,500	
Barani " 607 " at Rs. 400 " " ...	...	...	...	2,42,800	
		Total	...	5,39,275	
Compulsory acquisition at Rs. 15 per cent.	...	...	...	80,891	6,20,166
ABOHAR-BHATINDA FEEDER.					
<i>Ferozepore District.</i> —					
Mile 0 to 13.					
Chahi land, 33 acres, at Rs. 550 per acre ...	...	...	...	18,150	
Nahri " 166 " at Rs. 500 " " ...	...	...	...	83,000	
Barani " 522 " at Rs. 400 " " ...	...	...	...	2,08,800	
<i>Patiala State.</i> —					
Mile 13 to 20.					
Nahri land, 102 acres, at Rs. 450 per acre ...	...	...	...	45,900	
Barani " 252 " at Rs. 310 " " ...	...	...	...	78,120	
<i>Ludhiana District.</i> —					
Mile 20 to 25.					
Nahri land, 158 acres, at Rs. 400 per acre .	...	...	...	63,200	
Barani " 112 " at Rs. 220 " " ...	...	...	...	24,640	
		Total	...	5,21,810	
Compulsory acquisition at Rs. 15 per cent.	...	...	...	78,272	6,00,082
NOTE.—Rate of <i>Patiala State</i> is assumed as mean of <i>Ferozepore</i> and <i>Ludhiana Districts</i> .					
Carried over				...	17,43,492

B.—LAND—CONTINUED.

	Amount. Rs.	Total. Rs.
Brought forward ...	...	17,43,492
PHUL FEEDER.		
<i>Ludhiana District.—</i>		
From head to mile 1—2,500 feet.		
Nahri land, 14 acres, at Rs. 400 per acre ...	5,600	
Barani „ 56 „ „ 220 „ „ ...	13,320	
<i>Nabha State.—</i>		
From mile 1—2,500 feet to 6—1,000 feet ... 215 acres.		
Canal Station ... 50 „		
265 „		
Nahri land, 53 acres, at Rs. 450 per acre ...	23,850	
Barani „ 212 „ „ 285 „ „ ...	60,420	
Total ...	1,02,190	
Compulsory acquisition at Rs. 15 per cent. ...	15,329	1,17,519
Note.—Rate of Nabha State is the mean of Ludhiana (Jungle) and Ferozepore (Tehsil Nathana)		
RORI (A-9) FEEDER.		
<i>Patiala, Nabha and Jind States.—</i>		
Head to mile 32—1,000 feet.		
Barani land, 791 acres, at Rs. 220 per acre...	1,74,020	
Nahri „ 329 „ „ 350 „ „ ...	1,15,150	
<i>Hissar District.—</i>		
Mile 32—1,000 feet to 34—2,000 feet.		
Barani land, 156 acres, at Rs. 80 per acre ...	12,480	
Land in Sirsa for Divisional Office, Residential buildings, etc. Lump sum	5,000	
Total ...	3,06,650	
Compulsory acquisition at Rs. 15 per cent. ...	45,998	3,52,648
Barani. Nahri.		
Rates for States are taken mean of:—		
Ludhiana (Jungle) ...	220	400
Ferozepore (Nathana) ...	350	500
Hissar ...	80	160*
Total ...	650	1,060
Mean ...	220	350
*The rate of Barani land in Fatehabad Tehsil is half of Nahri land.		
Carried over ...	...	22,13,659

B.—LAND—CONCLUDED.

			Amount. Rs.	Total Rs.
Brought forward ...			...	22,13,659
BHATINDA-BIKANER FEEDER.				
<i>Patiala State.</i> —				
Barani land, 927 acres, at Rs. 250 per acre ...	...	...	2,37,500	
Nahri " 232 " " 375 " " ...	...	...	87,000	
<i>Ferozepore District.</i> —				
Barani land, 509 acres, at Rs. 350 per acre } <i>Nathana Tehsil</i> ...			1,78,150	
Nahri " 57 " " 500 " " }			28,500	
Barani " 135 " " 150 " " } <i>Fazilka Tehsil</i> ..			20,250	
Nahri " 15 " " 250 " " }			3,750	
Total ...	...	...	5,40,400	
Compulsory acquisition at Rs. 15 per cent. ...	..	...	82,410	6,31,810
NOTE.—Rate of Patiala State is mean of Nathana and Fazilka Tehsils of Ferozepore District.				
BIKANER BRANCHES.				
<i>Ferozepore District.</i> —				
Barani land, Main Branch, 60 acres.				
" " Border " 55 "				
Total ... 115 " at Rs. 150 per acre ...	...	...	17,250	
Nahri land, Border Branch, 106 " at Rs. 250 " " ...	...	...	26,500	
<i>Hissar District.</i> —				
Barani land, Main Branch, 152 acres.				
" " Border " 19 "				
Total ... 171 " at Rs. 80 per acre... ..	...	...	13,680	
<i>Bikaner State.</i> —				
Barani land, Main Branch, 1,368 acres.				
" " Border " 50 "				
Total ... 1,418 " at Rs. 10 per acre... ..	...	...	14,180	
Total ...	...	...	71,610	
Compulsory acquisition at Rs. 15 per cent. ...	...	...	10,742	82,352
GRAND TOTAL B.—LAND ...			...	29,27,821

NOTE.—Provision has been made in the detailed estimates for land for Rest-houses and canal station, etc., although not shown separately in the above abstracts as is done in the case of the Upper Sirhind Canal.

SUTLEJ DAM PROJECT

LOWER SIRHIND CANAL

2.—MAIN CANAL BRANCHES

D.—REGULATORS.

R. D. Miles. Feet.	MAIN LINE UPPER.	Amount. Rs.	Total. Rs.
0 0	Head Regulator— 16 spans of 20 feet, discharge 9,250 cusecs. Cost as detailed estimate ... ..	...	4,27,754
0 0	GREY CANAL FEEDER. Head Regulator at Tail of Main Line Upper— 2 spans of 20 feet, discharge 1,500 cusecs taking out at R. D. Mile 8—4,000 feet of Main Line Upper. Cost as detailed estimate ... ..	...	42,163
8 4,000	MAIN LINE LOWER. Head Regulator at Tail of Main Line Upper— 9 Bays of 20 feet each, discharge 8,242 cusecs. Cost as detailed estimate ... ..	...	1,35,701
0 0	ABOHAR-BHATINDA FEEDER. Head Regulator at Tail of Main Line Lower— 5 Bays of 20 feet each, foundations on wells, discharge 5,132 cusecs. Total cost of Head Regulator as detailed estimate including cost of Aqueduct for Wadhni Distributary... 1,16,056 <i>Deduct</i> —cost of Aqueduct taken under G. 1. ... 13,458 Cost of Regulator debitable to this head ... ..	...	1,02,598
0 0	PHUL FEEDER. Head Regulator at Tail of Abohar-Bhatinda Feeder— 4 Bays of 20 feet each, discharge 3,898 cusecs. Total cost of Head Regulator as detailed estimate, includ- ing cost of Aqueduct for Mari Minor ... 73,671 <i>Deduct</i> —cost of Aqueduct taken under G. 1. ... 11,858 Cost of Regulator debitable to this head ... ..	...	61,813
	Carried over ...	...	7,70,029

D.—REGULATORS—CONTINUED.

R. D.			Amount. Rs.	Total. Rs.
		Brought forward ...	...	7,70,029
		RORI (A-9) FEEDER.		
		Head Regulator at Tail of Phul Feeder—		
		2 spans of 20 feet each, discharge 1,464 cusecs.		
		Total cost of Head Regulator as detailed estimate including cost of Aqueduct for Bhundar Minor 48,117		
		Deduct—cost of Aqueduct taken under G. 1. ... 8,658		
		Cost of Regulator debitable to this head ...	39,459	
28	4,000	Regulating Bridge—		
		3 span of 10 feet each, discharge 815 cusecs.		
		Cost as detailed estimate ...	22,076	61,535
		BHATINDA-BIKANER FEEDER.		
0	0	Head Regulator at Tail of Phul Feeder		
		2 spans of 20 feet each, discharge 2,307 cusecs.		
		Cost of Head Regulator as detailed estimate ...	38,516	38,516
		BIKANER BRANCHES.		
		Bikaner Main Branch—		
0	0	Head Regulator at tail of Bhatinda-Bikaner Feeder.		
		2 Bays of 20 feet each, discharge 1,638 cusecs.		
		Cost of Head Regulator as per detailed estimate ...	35,052	
18	0	Regulating Bridge—		
		Cost taken by proportion from Regulating Bridge R.D. Mile 28—4,000 feet of Rori (A. 9.) Feeder.		
			Rs.	
		Rori Feeder Regulating Bridge ...	22,076	
		" " Bridge Upstream ...	12,300	
		" " Difference ...	9,776	
		i.e., 80 per cent. over and above the cost of Bridge.		
			Rs.	
		Cost of Bridge Upstream of this Regulating Bridge ...	11,740	
		Add—80 per cent. for Regulator ...	9,392	
		Total cost of Regulating Bridge ...	21,132	
32	3,000	Regulating Bridge and 7 feet Fall—		
			Rs.	
		Cost of Bridge Upstream of Fall ...	9,225	
		Add—80 per cent. for Regulator and Fall ...	7,380	
		Total cost of Regulating Bridge and 7 feet Fall ...	16,605	
		Carried over ...	72,789	8,70,080

D.—REGULATORS—CONCLUDED.

R. D.			Amount. Rs.	Total Rs.
		Brought forward ...	72,789	8,70,080
Miles. Feet.		BIKANER BRANCHES.—CONCLUDED.		
		BIKANER BORDER BRANCH.		
0	0	Head Regulator at tail of Bhatinda-Bikaner Feeder—		
		1 Bay of 20 feet, discharge 518 cusecs.		
		Cost of Head Regulator as per detailed estimate ...	24,056	
		Total Bikaner, Main Branch	72,789	
		Total Bikaner, Border Branch	24,056	96,845
		ABOHAR BRANCH ALTERATIONS.		
42	3,000	Head Regulator of Abohar Branch at Daudhar tail of Main Line Lower—		
		4 spans of 20 feet (Foundations on wells) discharge 3,074 cusecs.		
		Cost as detailed estimate	87,547	
48	635	Alterations to Lock Entrance of Sutlej Navigation Channel as Regulator for Sutlej Navigation Channel including lowering sill 1'66 feet ... Lump sum	5,000	92,547
		BHATINDA BRANCH ALTERATIONS.		
0	0	Head Regulator at Dhupali, tail of Abohar-Bhatinda Feeder—		
		2 Bays of 20 feet each, discharge 1,200 cusecs.		
		Cost of Regulator as detailed estimate	36,766	36,766
		GRAND TOTAL D.—REGULATORS ..	...	10,96,238

SUTLEJ DAM PROJECT

LOWER SIRHIND CANAL.

E.—FALLS.

R. D.			Amount. Rs.	Total Rs.
Miles. Feet.		GREY CANAL FEEDER.		
3 1,000		3'22 feet Fall and Bridge	12,000	
6 4,000		7'00 feet Fall and Bridge	16,000	
12 2,000		6'00 feet Fall and Bridge	15,000	
22 4,000		5'15 feet Fall and Bridge	14,000	57,000
		<i>Note.</i> —The cost of these works is taken from the Revised Project of the Upper Jhalum Canal, pages 42 and 47. A five feet Fall and V. R. Bridge at R. D. 50,000 of the Gujrat Branch has :— Downstream Bed width Ft. 03'0 Full supply depth 5'5 3 Spans of 21'00 The cost given is Rs. 14,000. The conditions are similar to those in the Gray Canal Feeder and the cost is taken proportionately.		
		BHATINDA-BIKANER FEEDER.		
5 4,000		8'5 feet Fall and V. R. Bridge— As detailed estimate. Cost of V. R. Bridge is Rs. 13,200 Extra for Fall 6,365	19,565	
15 0		2'5 feet Fall and V. R. Bridge— Cost of Bridge 13,200 Extra for 2'5 feet Fall— Half of Rs. 6,365 3,183	16,383	
22 2,000		9'0 feet Fall and V. R. Bridge— As detailed estimate for 8'5 feet Fall at R. D. 5-4,000'	19,565	55,513
		BIKANER MAIN BRANCH.		
9 0		3'0 feet Fall and Village Road Bridge— The Bhatinda-Bikaner Feeder Bridge and 8'5 feet Fall costs Rs. 19,565 and a bridge only Rs. 13,200 or an increase of 50 per cent. For 3 feet Fall take 33½ per cent. increase. V. R. Bridge on this Branch Upstream of this Fall costs 11,740 Add 33½ per cent. for Fall 3,918	15,658	
47 2,500		2'0 feet Fall and V. R. Bridge— The Bhatinda-Bikaner Feeder Bridge and 8'5 feet costs Rs. 19,565 and a bridge only Rs. 13,200 or an increase of 50 per cent. For 2 feet Fall take 25 per cent. increase. V. R. Bridge on this Branch Upstream of this Fall costs 7,200 Add 25 per cent. for Fall 1,800	9,000	24,658
		ABOHAR BRANCH ALTERATIONS.		
50 4,000		8 feet Fall and Bridge at Gholia— Lowering sill by 1'52 and re-building notches. Lump sum.		4,000
		BHATINDA BRANCH ALTERATIONS.		
61 2,000		8 feet Fall at Sadhana R. D. 3,07,000, Cutting down crest wall of Fall 3'14 feet and re-building notches. Lump sum.		5,000
GRAND TOTAL E.—FALLS				1,46,166

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

F.—RIVER AND HILL TORRENT WORKS.

R. D. Mile. Feet.	MAIN LINE UPPER.	Amount. Rs.	Total. Rs.
2 1,000	<p>Syphon for Budha Nala.</p> <p>3 barrels 8 feet diameter. Total length 273 feet; steel tubes under canal bed.</p> <p>Cost as detailed estimate 88,176</p> <p>Diversion cut for Budha Nala above Syphon. Lump sum 8,000</p>		96,176
10 2,000	<p>MAIN LINE LOWER.</p> <p>Drainage inlet 1 span of 8 feet.</p> <p>The cost of this work is taken from that of inlet at mile 2—2,000 feet of Abohar-Bhatinda Feeder—</p> <p>Abutment and half arch, 2 No. at Rs. 2,060 each .. 4,120</p>		
15 3,000	<p>Drainage inlet 1 span of 8 feet.</p> <p>The cost of this work is taken from that of inlet at mile 2—2,000 feet of Abohar-Bhatinda Feeder—</p> <p style="text-align: right;">Rs.</p> <p>Abutment and half arch, 2 No. at Rs. 2,060 4,120 each.</p> <p>Add 50 per cent. for extra depth ... 2,060</p>	6,180	
20 500	<p>Drainage inlet 2 spans of 8 feet.</p> <p>The cost of this work is taken from that of inlet at mile 2—2,000 feet of Abohar-Bhatinda Feeder—</p> <p style="text-align: right;">Rs.</p> <p>Abutment and half arch, 2 No. at Rs. 2,060 4,120 each.</p> <p>Pier and 1 span, 1 No. at Rs. 1,310 each 1,310</p>	5,430	
26 1,000	<p>Drainage inlet 3 spans of 8 feet.</p> <p>The cost of this work is taken from that of inlet at mile 2—2,000 feet of Abohar-Bhatinda Feeder—</p> <p style="text-align: right;">Rs.</p> <p>Abutment and half arch, 2 No. at Rs. 2,060 4,120 each.</p> <p>Pier and 1 span, 2 No. at Rs. 1,310 each ... 2,620</p>	6,740	22,470
	Carried over	..	1,18,646

F.—RIVER AND HILL TORRENT WORKS—CONCLUDED.

R. Mile.	D. Feet.		Amount. Rs.	Total. Rs.
		Brought forward ...	...	1,18,646
		ABOHAR-BHATINDA FEEDER.		
2	2,000	Drainage inlet 5 spans of 8 feet. Rs. Abutment and half arch as detailed estimate, 2 No. at Rs. 2,060 each. Pier and 1 span as detailed estimate, 4 No. at Rs. 1,310 each.	4,120 5,240 9,360	
6	3,500	Drainage inlet 1 span of 8 feet. The cost of this work is taken from that of drainage inlet at mile 2—2,000 feet above— Rs. Abutment and half arch, 2 No. at Rs. 2,060 each	4,120	
14	3,000	Drainage inlet 1 span of 8 feet. The cost of this work is taken from that of drainage inlet at mile 2—2,000 feet above— Rs. Abutment and half arch, 2 No. at Rs. 2,060 each	4,120	17,600
		BIKANER MAIN BRANCH.		
1	4,500	Syphon 1 barrel of 5 feet diameter ... The bed of this branch is 36 feet, that of the Rori Feeder is 35 feet, so that the cost of this syphon can be taken to be the same as that of syphon for Sandholia Branch under the Rori (A-9) Feeder at R. D. mile 19-200 feet, estimated in detail under G. I. Canal Crossings.	7,425	
16	3,500	Syphon 1 barrel of 5 feet diameter. Cost taken same as for syphon at R. D. mile 1—4,500 feet above	7,425	
22	0	Syphon 1 barrel of 5 feet diameter. Cost taken same as for syphon at mile 1—4,500 feet above	7,425	
26	2,500	Syphon 1 barrel of 5 feet diameter. Cost taken same as for syphon at mile 1—4,500 feet above	7,425	29,700
		GRAND TOTAL F.—RIVER AND HILL TORRENT WORKS ...		1,43,946

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

G. - BRIDGES.

R. D. Miles. Feet.	MAIN LINE UPPER.	Amount. Rs.	Total. Rs.
2 2,000	Village Road Bridge, 8 spans of 24 feet, 10 feet Roadway— Rs. Abutment and half span, 2 No. at Rs. 5,400 each 10,800 Pier and 1 span, 7 No. at Rs. 2,680 each ... 18,760 Add for wet foundations ... 2,000	31,560	
3 2,000	V. R. Bridge, 8 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 2—2,000 feet ...	31,560	
4 4,000	District Road Bridge, 14 feet Roadway—8 spans of 24 feet. Rs. Abutment and half span for 16 feet Roadway— 2 No. at Rs. 5,400 each ... 10,800 For extra width 2 x 4 feet at Rs. 145 per foot 1,160 Pier and 1 span for 10 feet Roadway— 7 No. at Rs. 2,680 each ... 18,760 For extra width 7 x 4 feet at Rs. 106 per foot 2,068 Add for wet foundations ... 2,000	35,688	
6 4,000	V. R. Bridge, 8 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 2—2,000 feet ...	31,560	1,30,368
	GREY CANAL FEEDER.		
1 2,000	Village Road Bridge, 3 spans of 20 feet, 10 feet Roadway— Rs. Abutment and half span, 2 No. at Rs. 4,500 each 9,000 Pier and 1 span, 2 No. at Rs. 2,100 each ... 4,200	13,200	
3 3,200	Existing Village Road Bridge Alterations, Lump sum ...	5,000	
4 1,000	Existing Village Road Bridge Alterations, Lump sum ...	5,000	
9 1,000	V. R. Bridge, 3 spans of 22 feet, 10 feet Roadway— Rs. Abutment and half span, 2 No. at Rs. 4,450 each 8,900 Pier and 1 span, 2 No. at Rs. 2,200 each ... 4,580	13,480	
11 1,500	V. R. Bridge, 3 spans of 22 feet, 10 feet Roadway— Same as V. R. Bridge at mile 9—1,000 feet ...	13,480	
13 2,000	V. R. Bridge, 2 spans of 22 feet, 10 feet Roadway— Rs. Abutment and half span— 2 No. at Rs. 4,200 each ... 8,400 Pier and 1 span— 1 No. at Rs. 2,240 each ... 2,240	10,640	
15 3,000	V. R. Bridge, 2 spans of 22 feet, 10 feet Roadway— Same as V. R. Bridge at mile 13—2,000 feet ...	10,640	
17 2,000	V. R. Bridge, 2 spans of 22 feet, 10 feet Roadway— Same as V. R. Bridge at mile 13—2,000 feet ...	10,640	
18 4,500	V. R. Bridge, 2 spans of 22 feet, 10 feet Roadway— Same as V. R. Bridge at mile 13—2,000 feet ...	10,640	
20 4,000	V. R. Bridge, 2 spans of 22 feet, 10 feet Roadway— Same as V. R. Bridge at mile 13—2,000 feet ...	10,640	
25 3,500	V. R. Bridge, 2 spans of 16 feet, 10 feet Roadway— Rs. Abutment and half span No. 2 at Rs. 3,475 each 6,950 Pier and 1 span, No. 1 at Rs. 1,495 each ... 1,495	8,445	1,11,805
	Carried over ...	...	2,42,173

G.—BRIDGES—CONTINUED.

R. D. Miles. Feet.		Amount. Rs.	Total. Rs.
	Brought forward ...	...	2,42,173
	MAIN LINE LOWER.		
10 1,000	Village Road Bridge, 7 spans of 25 feet, 10 feet Roadway— Rs. Abutment and half span, 2 No. at Rs. 5,500 each 11,000 Pier and 1 span, 6 No. at Rs. 2,800 each ... 16,800 Add per wet foundations ... 2,000	29,800	
12 500	V. R. Bridge, 7 spans of 25 feet, 10 feet Roadway— Same as V. R. Bridge at mile 10—1,000 feet ...	29,800	
13 4,000	V. R. Bridge, 7 spans of 25 feet, 10 feet Roadway— Same as V. R. Bridge at mile 10—1,000 feet ...	29,800	
15 1,500	V. R. Bridge, 7 spans of 25 feet, 10 feet Roadway— Same as V. R. Bridge at mile 10—1,000 feet ...	29,800	
17 500	District Road Bridge, 7 spans of 25 feet 14 feet Roadway— Rs. Abutment and half span for 10 feet Roadway— 2 No. at Rs. 5,500 each ... 11,000 For extra width 2 x 4 feet at Rs. 150 per foot 1,200 Pier and 1 span for 10 feet Roadway— 6 No. at Rs. 2,800 each ... 16,800 For extra width 6 x 4 feet at Rs. 110 per foot 2,640	31,640	
19 1,205	Grand Trunk Road Bridge, 7 spans of 25 feet, 16 feet Roadway— Rs. Abutment and half span for 10 feet Roadway— 2 No. at Rs. 5,500 each ... 11,000 For extra width 2 x 6 feet at Rs. 150 per foot 1,800 Pier and 1 span for 10 feet Roadway— 6 No. at Rs. 2,800 each ... 16,800 For extra width 6 x 6 feet at Rs. 110 per foot 3,960	33,560	
19 3,165	Railway Bridge, Ludhiana-Ferozepore Railway— The cost of Railway Bridges including diversion of Railway Line is taken from the mean actual costs of Railway Bridges constructed in the Triple Canal Project at Rs. 400 per foot of bed: 163 feet at Rs. 400 per foot Rs. 65,200...	65,200	
21 1,360	Jagraon Distributary Crossing— V. R. Bridge and Aqueduct, 7 spans of 25 feet, 10 feet Roadway— Rs. Abutment and half span, No. 2 at Rs. 5,500 each 11,000 Pier and 1 span, No. 6 at Rs. 2,800 each ... 16,800	27,800	
	NOTE.—The Jagraon Distributary is carried across the canal in an aqueduct combined with the bridge at this site; the cost of the bridge alone is provided under this sub-head. The total cost of the combined work less the cost of a bridge, being the cost of taking the Distributary across, is provided under G-I. Canal Crossings.		
22 3,000	V. R. Bridge, 7 spans of 25 feet, 10 feet Roadway— Same as V. R. Bridge at mile 21—1,360 feet ...	27,800	
24 2,655	Daudhar Branch Crossing— V. R. Bridge and Aqueduct spans of 25 feet, 10 feet Roadway— Same as V. R. Bridge at mile 21—1,360 ...	27,800	
	NOTE.—The Daudhar Branch is carried across in conjunction with this bridge, the cost is estimated as in the case of Jagraon Distributary, and provided under G. I. Canal Crossings.		
	Carried over ...	33, 3,000	2,42,173

G.—BRIDGES—CONTINUED.

R. D. Mile. Feet.		Amount. Rs.	Total. Rs.
	MAIN LINE LOWER—CONCLUDED.		
	Brought forward ...	3,33,000	2,42,173
25 8,000	V. R. Bridge, 7 spans of 25 feet, 10 feet Roadway— Same as V. R. Bridge at mile 21—1,360 feet ...	27,800	3,60,800
	ABOHAR-BHATINDA FEEDER.		
2 500	Village Road Bridge, 5 spans of 24 feet, 10 feet Roadway— Rs. Abutment and half span No. 2 at Rs. 5,150 each 10,300 Pier and 1 span No. 4 at Rs. 2,630 each ... 10,520	20,820	
3 4,000	V. R. Bridge, 5 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 2—500 feet ...	20,820	
6 500	District Road Bridge, 5 spans of 24 feet, 14 feet Roadway— Abutment and half span for 10 feet Roadway— Rs. 2 No. at Rs. 5,150 each ... 10,300 For extra width 2 × 4 feet at Rs. 139 per foot 1,112 Pier and 1 span for 10 feet Roadway— 4 No. at Rs. 2,630 each ... 10,520 For extra width 4 × 4 feet at Rs. 165 per foot 1,680	28,612	
8 0	V. R. Bridge, 5 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 2—500 feet ...	20,820	
9 4,100	V. R. Bridge, 5 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 2—500 feet ...	20,820	
11 4,500	V. R. Bridge, 5 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 2—500 feet ...	20,820	
13 1,500	V. R. Bridge, 5 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 2—500 feet ...	20,820	
15 8,500	V. R. Bridge, 5 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 2—500 feet ...	20,820	
17 500	Bhadaur Distributary Crossing— V. R. Bridge and Aqueduct, 5 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 2—500 feet ... NOTE.—The Bhadaur Distributary is carried across in conjunction with this bridge. The cost is estimated as in the case of the Jagraon Distributary Crossing over the Main Line, and charged to G. I. Canal Crossings.	20,820	
19 2,000	V. R. Bridge, 5 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 2—500 feet ...	20,820	
20 4,800	Ganda Banna Minor Crossing— V. R. Bridge and Aqueduct, 5 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 2—500 feet ... NOTE.—The Ganda Banna Minor is carried across in conjunction with this bridge. The cost is estimated as in the case of the Jagraon Distributary Crossing over the Main Line, and charged to G. I. Canal Crossings.	20,820	
22 2,333	Dhipali Distributary Crossing— V. R. Bridge and Aqueduct, 5 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 2—500 feet ... NOTE.—The Dhipali Distributary is carried across in conjunction with this bridge. The cost is estimated as in the case of the Jagraon Distributary Crossing over the Main Line, and charged to G. I. Canal Crossings.	20,820	
23 2,500	V. R. Bridge, 5 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 2—500 feet ...	20,820	2,73,452
	Carried over ...	...	8,76,425

G.—BRIDGES—CONTINUED.

R. D. Mile.	Feet.		Amount. Rs.	Total. Rs.
		Brought forward ...		8,76,425
		PHUL FEEDER.		
2	500	Village Road Bridge, 4 spans of 24 feet, 10 feet Roadway— Abutment and half arch 2 No. at Rs. 5,150 each Rs. 10,300 Pier and 1 span No. 3 at Rs. 2,630 each ... „ 7,890	18,190	
3	4,500	V. R. Bridge, 4 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 2—500 feet ..	18,190	
5	4,100	Phul Distributary Crossing— V. R. Bridge and Aqueduct, 4 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 2—500 feet	18,190	
		Note.—The Phul Distributary is carried across in conjunction with this bridge and the cost is estimated as in the case of the Bahadur Distributary Crossing over the Abohar-Bhatinda Feeder and charged G. I. Canal Crossings.		
6	780	Railway Bridge, Southern Punjab, Dhuri-Bhatinda, Railway— The cost of Railway Bridges including diversion of Railway Line is taken from the mean actual costs of Railway Bridges constructed in the Triple Canal Project at Rs. 400 per foot of bed— Rs. 85 feet at Rs. 400 per foot... 34,000	34,000	88,570
		ROHRI (A-9) FEEDER.		
1	2,000	Village Road Bridge, 2 spans of 24 feet, 10 feet Roadway— Abutment and half arch 2 No. at Rs. 4,900 each Rs. 9,800 Pier and 1 span, 1 No. at Rs. 2,580 each „ 2,580	12,380	
3	0	V. R. Bridge, 2 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—2,000 feet ...	12,380	
5	0	V. R. Bridge, 2 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—2,000 feet ...	12,380	
5	3,700	V. R. Bridge, 2 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—2,000 feet ...	12,380	
7	500	V. R. Bridge, 2 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—2,000 feet ...	12,380	
9	0	V. R. Bridge, 2 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—2,000 feet ...	12,380	
10	4,000	V. R. Bridge, 2 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—2,000 feet ...	12,380	
12	500	V. R. Bridge, 2 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—2,000 feet ...	12,380	
14	300	V. R. Bridge, 2 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—2,000 feet ...	12,380	
15	1,500	V. R. Bridge, 2 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—2,000 feet ...	12,380	
16	1,130	Railway Bridge, Southern Punjab, Bhatinda-Jakhal, Railway— The cost of Railway Bridges including diversion of Railway Line is taken from the mean actual costs of Railway Bridges constructed in the Triple Canal Project, at Rs. 400 per foot of bed— Rs. 38 feet at Rs. 400 per foot ... 15,200	15,200	
16	4,530	Maur Branch Crossing— V. R. Bridge and Aqueduct, 2 spans of 24 feet, 10 feet Roadway—Same as V. R. Bridge at mile 1—2,000 feet ...	12,380	
		Note.—The Maur Branch is carried across in conjunction with the Bridge and the cost is estimated as in the case of the Jagraon Distributary Crossing over the Main Line and charged to G. I. Canal Crossings.		
		Carried over ...	1,51,380	9,64,995

G.—BRIDGES—CONTINUED.

R. D. Mile. Feet.		Amount. Rs.	Total. Rs.
RORI (A9.) FEEDER—CONCLUDED			
	Brought forward	1,51,380	9,64,995
18 2,000	V. R. Bridge, 2 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—2,000 feet	12,380	
19 200	V. R. Bridge, 2 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—2,000 feet	12,380	
21 1,500	V. R. Bridge, 2 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—2,000 feet	12,380	
22 3,000	V. R. Bridge, 2 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—2,000 feet	12,380	
24 600	V. R. Bridge, 2 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—2,000 feet	12,380	
26 0	V. R. Bridge, 2 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—2,000 feet	12,380	
27 3,500	V. R. Bridge, 2 spans of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—2,000 feet	12,380	
30 2,000	V. R. Bridge, 2 spans of 16 feet, 10 feet Roadway— Abutment and half arch 2 No. at Rs. 3,850 each 7,700 Pier and 1 span 1 No. at Rs. 1,570 each ... 1,570	9,270	
32 250	V. R. Bridge, 2 spans of 16 feet, 10 feet Roadway— Same as V. R. Bridge at mile 30—2,000 feet	9,270	2,56,580
BHATINDA-BIKANER FEEDER.			
1 3,500	Village Road Bridge, 3 spans of 20 feet, 10 feet Roadway— Abutment and $\frac{1}{2}$ arch, 2 No. at Rs. 4,500 each... 9,000 Pier and 1 span, 2 No. at Rs. 2,100 each ... 4,200	13,200	
3 3,500	V. R. Bridge, 3 spans of 20 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,500 feet	13,200	
6 3,000	V. R. Bridge, 3 spans of 20 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,500 feet	13,200	
8 2,000	V. R. Bridge, 3 spans of 20 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,500 feet	13,200	
11 2,000	V. R. Bridge, 3 spans of 20 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,500 feet	13,200	
12 3,000	V. R. Bridge, 3 spans of 20 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,500 feet	13,200	
17 4,000	V. R. Bridge, 3 spans of 20 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,500 feet	13,200	
19 3,000	V. R. Bridge, 3 spans of 20 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,500 feet	13,200	
19 4,250	Railway Bridge, Southern Punjab Railway, Bhatinda to Jakhal, The cost of Railway Bridges including diversion of Railway Line is taken from the mean actual costs of Railway Bridges constructed in the Triple Canal Project at Rs. 400 per foot of bed— 52 feet at Rs. 400 per foot ... 20,800	20,800	
Carried over		1,26,400	12,21,575

G.—BRIDGES—CONTINUED.

R. D. Miles. feet.		Amount. Rs.	Total. Rs.
	BHATINDA-BIKANER FEEDER—CONCLUDED.		
	Brought forward ...	1,26,400	12,21,575
21 0	V. R. Bridge, 3 spans of 20 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,500 feet ...	13,200	
22 3,300	Railway Bridge, Rajputana-Malwa Railway, Bhatinda to Sirsa (metre gauge)— Same rate is given as for Broad Gauge, Rs. 400 per foot of bed— 52 feet at Rs. 400 per foot Rs. 20,800	20,800	
23 4,000	V. R. Bridge and Aqueduct, 3 spans of 20 feet, 10 feet Road- way— Same as V. R. Bridge at mile 1—3,500 feet ..	13,200	
	Note.—The Mehta Branch of Bhatinda Distributary is carried across in conjunction with this Bridge and the cost is estimated and charged to G. I Canal Crossings.		
25 4,000	V. R. Bridge, 3 spans of 20 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,500 feet ...	13,200	
27 800	Railway Bridge, Jodhpur-Bikaner Railway, Bhatinda to Hanumangarh (meter gauge)— Same rate is given as for Broad Gauge, Rs. 400 per foot of bed— 52 feet at Rs. 400 per foot Rs. 20,800	20,800	
27 4,000	V. R. Bridge, 3 spans of 20 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,500 feet ...	13,200	
29 3,000	V. R. Bridge, 3 spans of 20 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,500 feet ...	13,200	
31 0	V. R. Bridge, 3 spans of 20 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,500 feet ...	13,200	
33 4,000	V. R. Bridge, 3 spans of 20 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,500 feet ...	13,200	
36 1,000	V. R. Bridge, 3 spans of 20 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,500 feet ...	13,200	
38 3,000	V. R. Bridge, 3 spans of 20 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,500 feet ...	13,200	
41 4,000	V. R. Bridge, 3 spans of 20 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,500 feet ...	13,200	
43 3,000	V. R. Bridge, 3 spans of 20 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,500 feet ...	13,200	3,13,200
	BIKANER MAIN BRANCH.		
3 2,000	Village Road Bridge, 2 spans of 22 feet, 10 feet Roadway— Rs. Abutment and $\frac{1}{2}$ arch 2 No. at Rs. 4,700 each 9,400 Pier and 1 span 1 No. at Rs. 2,340 each ... 2,340	11,740	
6 3,000	V. R. Bridge, 2 spans of 22 feet, 10 feet Roadway— Same as V. R. Bridge at mile 3—2,000 feet ...	11,740	
12 0	V. R. Bridge, 2 spans of 22 feet, 10 feet Roadway— Same as V. R. Bridge at mile 3—2,000 feet ...	11,740	
14 3,500	V. R. Bridge, 2 spans of 22 feet, 10 feet Roadway— Same as V. R. Bridge at mile 3—2,000 feet ...	11,740	
17 0	V. R. Bridge, 2 spans of 22 feet, 10 feet Roadway— Same as V. R. Bridge at mile 3—2,000 feet ...	11,740	
	Carried over ...	58,700	15,34,775

G—BRIDGES—CONCLUDED.

R. D. Miles. Feet.	BIKANER MAIN BRANCH—CONCLUDED.		Amount. Rs.	Total. Rs.
		Brought forward ...	58,700	15,34,775
21 0	Village Road Bridge, 2 spans of 15 feet, 10 feet Roadway— Rs. Abutment and $\frac{1}{2}$ arch 2 No. at Rs. 3,875 each ... 7,750 Pier and 1 span 1 No. at Rs. 1,475 each ... 1,475		9,225	
24 0	V. R. Bridge, 2 spans of 15 feet, 10 feet Roadway— Same as V. R. Bridge at mile 21-0 feet ...		9,225	
27 0	V. R. Bridge, 2 spans of 15 feet, 10 feet Roadway— Same as V. R. Bridge at mile 21-0 feet ...		9,225	
29 3,000	V. R. Bridge, 2 spans of 15 feet, 10 feet Roadway— Same as V. R. Bridge at mile 21-0 feet ...		9,225	
34 3,000	V. R. Bridge, 1 span of 18 feet, 10 feet Roadway— Rs. Abutment and $\frac{1}{2}$ arch 2 No. at Rs. 3,600 each 7,200...		7,200	
37 3,000	V. R. Bridge, 1 span of 18 feet, 10 feet Roadway— Same as V. R. Bridge at mile 34—3,000 feet ...		7,200	
40 2,000	V. R. Bridge, 1 span of 18 feet, 10 feet Roadway— Same as V. R. Bridge at mile 34—3,000 feet ...		7,200	
43 0	V. R. Bridge, 1 span of 18 feet, 10 feet Roadway— Same as V. R. Bridge at mile 34—3,000 feet ...		7,200	
45 3,000	V. R. Bridge, 1 span of 18 feet, 10 feet Roadway— Same as V. R. Bridge at mile 34—3,000 feet ...		7,200	
50 2,000	V. R. Bridge, 1 span of 18 feet, 10 feet Roadway— Same as V. R. Bridge at mile 34—3,000 feet ...		7,200	1,38,800
	BIKANER BORDER BRANCH.			
1 3,000	V. R. Bridge, 1 span of 24 feet, 10 feet Roadway— Abutment and $\frac{1}{2}$ arch 2 No. at Rs. 4,400 each 8,800 ...		8,800	
3 4,000	V. R. Bridge, 1 span of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,000 feet ...		8,800	
6 0	V. R. Bridge, 1 span of 24 feet, 10 feet Roadway— Same as V. R. Bridge at mile 1—3,000 feet ... Rs. Rs.		8,800	26,400
	Total Bikaner Branches 1,38,800 + 26,400 ...		...	1,65,200
	ABOHAR BRANCH ALTERATIONS.			
45 2,857	V. R. Bridge existing, 2 spans of 42 feet— $\text{Existing Velocity } \frac{2,417}{2 \times 42 \times 8} = \frac{2,417}{672} = 3.44$ $\text{Proposed Velocity } \frac{3,074}{2 \times 42 \times 9} = \frac{3,074}{756}$ Lowering floor by 2 feet and extra protection for increase of velocity, lump sum ...		4,000	
48 850	Girder Foot Bridge— Lowering floor by 1'66 and extra protection for increase of velocity, lump sum ...		2,000	600.0
	BHATINDA BRANCH ALTERATIONS.			
	V. R. Bridge across Bhatinda Branch. Up-stream of Junction Abohar Bhatinda Feeder, 3 spans of 20 feet, 10 feet Roadway— Rs. Abutment and $\frac{1}{2}$ span 2 No. at Rs. 4,750 each ... 9,500 Pier and 1 span 2 No. at Rs. 2,150 ... 4,300		13,800	13,800
	GRAND TOTAL G.—BRIDGES ...		...	17,19,775

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

G. 1.—CANAL CROSSINGS.

R. D. Mile. Feet.	MAIN LINE LOWER.	Amount. Rs.	Total. Rs.														
21 1,360	<p>Aqueduct for <i>Jagraon Distributary</i>, R. D. 47,400 feet, discharge 111 cusecs, combined with V. R. Bridge, 7 spans of 25 feet; the road being carried on the top of the Aqueduct which is 10 feet bed width and 3 feet deep. Designed and estimated in detail—</p> <table><tr><td>Cost of abutment and half arch, 2 No.</td><td>Rs.</td></tr><tr><td>at Rs. 11,065 each ...</td><td>22,130</td></tr><tr><td>Cost of pier and 1 span, 6 No. at Rs. 3,962 each ...</td><td>23,772</td></tr><tr><td>Total cost ...</td><td>45,902</td></tr><tr><td>Deduct cost of bridge provided under G. Bridges ...</td><td>27,800</td></tr><tr><td>Balance debitabte to this head ...</td><td>18,102</td></tr></table>	Cost of abutment and half arch, 2 No.	Rs.	at Rs. 11,065 each ...	22,130	Cost of pier and 1 span, 6 No. at Rs. 3,962 each ...	23,772	Total cost ...	45,902	Deduct cost of bridge provided under G. Bridges ...	27,800	Balance debitabte to this head ...	18,102	18,102			
Cost of abutment and half arch, 2 No.	Rs.																
at Rs. 11,065 each ...	22,130																
Cost of pier and 1 span, 6 No. at Rs. 3,962 each ...	23,772																
Total cost ...	45,902																
Deduct cost of bridge provided under G. Bridges ...	27,800																
Balance debitabte to this head ...	18,102																
24 2,655	<p>No change in the Distributary is necessary.</p> <p>Aqueduct for <i>Daodhar Branch</i> of <i>Jagraon Distributary</i>, R. D. 20,500 feet, discharge 14.5 cusecs, 3 feet diameter steel pipe; carried over on piers of V. R. Bridge, 7 spans of 25 feet. Designed and estimated in detail—</p> <table><tr><td>Cost of V. R. Bridge ...</td><td>Rs. 27,800</td></tr><tr><td>Extra cost Aqueduct as detailed estimate—</td><td></td></tr><tr><td>Cost for abutment and half arch, 2 No. at Rs. 3,987 each ...</td><td>7,974</td></tr><tr><td>Cost for pier and 1 span, 6 No. at Rs. 922 each ...</td><td>5,532</td></tr><tr><td>Total cost ...</td><td>41,306</td></tr><tr><td>Deduct cost of bridge provided under G. Bridges ...</td><td>27,800</td></tr><tr><td>Balance debitabte to this head ...</td><td>13,506</td></tr></table>	Cost of V. R. Bridge ...	Rs. 27,800	Extra cost Aqueduct as detailed estimate—		Cost for abutment and half arch, 2 No. at Rs. 3,987 each ...	7,974	Cost for pier and 1 span, 6 No. at Rs. 922 each ...	5,532	Total cost ...	41,306	Deduct cost of bridge provided under G. Bridges ...	27,800	Balance debitabte to this head ...	13,506	13,506	31,608
Cost of V. R. Bridge ...	Rs. 27,800																
Extra cost Aqueduct as detailed estimate—																	
Cost for abutment and half arch, 2 No. at Rs. 3,987 each ...	7,974																
Cost for pier and 1 span, 6 No. at Rs. 922 each ...	5,532																
Total cost ...	41,306																
Deduct cost of bridge provided under G. Bridges ...	27,800																
Balance debitabte to this head ...	13,506																
0 0	<p>ABOHAR-BHATINDA FEEDER.</p> <p>Aqueduct for <i>Wadni Distributary</i>, R. D. 4,827 feet; discharge 60 cusecs, steel trough 5 feet x 5 feet; carried over on piers of Head Regulator of Abohar-Bhatinda Feeder, 5 spans of 20 feet, extra cost of aqueduct being taken the same as that for Bhadaur Distributary—</p> <table><tr><td>Cost for abutment and half arch, 2 No. at Rs. 3,529 each ...</td><td>Rs. 7,058</td></tr><tr><td>Cost for pier and 1 span, 4 No. at Rs. 1,600 each ...</td><td>6,400</td></tr><tr><td>Total cost for Aqueduct ...</td><td>13,458</td></tr><tr><td>Total cost of Head Regulator including cost of Aqueduct ...</td><td>1,16,056</td></tr><tr><td>Balance cost of Head Regulator taken under D. Regulators ...</td><td>1,02,598</td></tr><tr><td>Extra cost of Aqueduct chargeable to the sub-head ...</td><td>13,458</td></tr></table>	Cost for abutment and half arch, 2 No. at Rs. 3,529 each ...	Rs. 7,058	Cost for pier and 1 span, 4 No. at Rs. 1,600 each ...	6,400	Total cost for Aqueduct ...	13,458	Total cost of Head Regulator including cost of Aqueduct ...	1,16,056	Balance cost of Head Regulator taken under D. Regulators ...	1,02,598	Extra cost of Aqueduct chargeable to the sub-head ...	13,458				
Cost for abutment and half arch, 2 No. at Rs. 3,529 each ...	Rs. 7,058																
Cost for pier and 1 span, 4 No. at Rs. 1,600 each ...	6,400																
Total cost for Aqueduct ...	13,458																
Total cost of Head Regulator including cost of Aqueduct ...	1,16,056																
Balance cost of Head Regulator taken under D. Regulators ...	1,02,598																
Extra cost of Aqueduct chargeable to the sub-head ...	13,458																
	Carried over	31,608														

G. 1.—CANAL CROSSINGS—CONTINUED.

R. D. Mile. Feet.		Amount. Rs.	Total. Rs.
	ABOHAR-BHATINDA FEEDER—CONCLUDED.		
	Brought forward ...	...	31 608
	Diverting Wadni Distributary over Aqueduct at Head Regulator of Abohar-Bhatinda Feeder and constructing Distributary parallel to the Feeder to supply the tail reaches of the Raikot and Manoki Distributaries—		
	Rs. 10 miles at Rs. 4,500 per mile ... 45,000		
	Cost of Aqueduct 13,458		
	Total cost chargeable to the Sub-head ...	58,458	
17 500	Aqueduct for Bhadaur Distributary R. D. 34,954, discharge 139·1 cusecs, steel trough 5 feet x 5 feet. Carried over on piers of V. R. Bridge, 5 spans of 24 feet. Designed and estimated in detail—		
	Cost for abutment and half arch, 2 No. Rs. at Rs. 3,529 each 7,058		
	Cost for pier and 1 span, 4 No. at Rs. 1,600 each 6,400		
	Cost of V. R. Bridge as per Statement of G. Bridges 20,820		
	Total cost of V. R. Bridge and Aqueduct 34,278		
	Deduct cost of V. R. Bridge taken under G. Bridges 20,820		
	Extra cost of Aqueduct chargeable to this head 13,458		
	Remodelling Bhadaur Distributary, 3 feet rise in full supply level from crossing to 3·5 feet Fall at R. D. 28,030 feet—		
	Raising banks of Distributary for 2 miles at Rs. 2,000 per mile 4,000		
	Raising 2 No. bridges at Rs. 1,000 each ... 2,000		
	Constructing new Fall below crossing, 1 No. at Rs. 2,500 each 2,500		
	Total cost for remodelling 8,500		
	Cost of Aqueduct 13,458		
	Total cost chargeable to this sub-head ...	21,958	
20 4,800	Aqueduct for Ganda-Banna Minor of Dhipali Distributary R. D. 7,905, discharge 5·97 cusecs, steel trough 3 feet x 3 feet. Carried over on piers of V. R. Bridge, 5 spans of 24 feet. Designed and estimated in detail—		
	Cost for abutment and half arch, 2 No. at Rs. 2,618 each 5,236		
	Cost for Pier and 1 span, 4 No. at Rs. 1,057 each 4,228		
	Cost of V. R. Bridge as per Statement of G. Bridges 20,820		
	Total cost of V. R. Bridge and Aqueduct ... 30,284		
	Deduct cost of V. R. Bridge taken under G. Bridges 20,820		
	Cost of Aqueduct chargeable to this sub-head 9,464		
	Carried over ...	80,416	31,608

G. 1.—CANAL CROSSINGS—CONTINUED.

Mile.	D. Feet.		Amount. Rs.	Total. Rs.
		ABOHAR-BHATINDA FEEDER—CONCLUDED.		
		Brought forward ...	80,416	31,608
		Remodelling Gandu-Banna Minor from crossing to the Head of the Minor—		
		Raising banks of Minor 1·4 miles at Rs. 500 per mile ...	700	
		Raising No. 3 bridges at Rs. 500 each ...	1,500	
		Remodelling Head of Minor ...	1,000	
		Total cost for remodelling ...	3,200	
		Cost of Aqueduct ...	9,464	
		Cost of remodelling the Minor ...	3,200	
		Total cost chargeable to this sub-head ...	12,664	12,664
22	2,333	Aqueduct for <i>Dhipali Distributary</i> R. D. 62,972 feet, discharge 61 cusecs. steel trough 5 feet x 5 feet. Carried over on piers of V. R. Bridge, 5 spans of 24 feet. Designed and estimated in detail—		
		Cost for abutment and half arch, 2 No. at Rs. 2,870 each ...	5,740	
		Cost for pier and 1 span, 4 No. at Rs. 1,600 each ...	6,400	
		Cost of V. R. Bridge as per Statement of G. Bridges ...	20,820	
		Total cost of V. R. Bridge and Aqueduct ...	32,960	
		Deduct cost of V. R. Bridge taken under G. Bridges ...	20,820	
		Cost of Aqueduct chargeable to this sub-head ...	12,140	
		Remodelling <i>Dhipali Distributary</i> . Raising Full Supply level 2·8 feet from crossing to 2 feet Fall at R. D. 56,435 feet of the Distributary—		
		Raising banks of Distributary 1·3 miles at Rs. 1,200 per mile ...	1,560	
		Raising 1 No. V. R. Bridge, at Rs. 600 each ...	600	
		Constructing new Fall below crossing 1 No. at Rs. 1,500 ...	1,500	
		Cost of remodelling lower reach ...	3,660	
		Raising Full Supply level 0·8 feet from 2 feet Fall R. D. 56,435 feet to 0·8 feet Fall at R. D. 38,500 feet—		
		Raising banks of Distributary 3·6 miles at Rs. 500 per mile ...	1,800	
		Raising 4 No. bridges at Rs. 400 each ...	1,600	
		Cost of remodelling Upper reach ...	3,400	
		Cost of remodelling Lower reach ...	3,660	
		Total cost of remodelling ...	7,060	
		Cost of Aqueduct ...	12,140	
		Total cost chargeable to this sub-head ...	19,200	1,12,280
		Carried over ...	...	1,43,888

G. 1.—CANAL CROSSINGS—CONTINUED.

R. D. Mile. Feet.		Amount. Rs.	Total. Rs.
	Brought forward	...	1,43,888
	PHUL FEEDER.		
0 0	Aqueduct for <i>Mari Minor</i> steel trough 5 feet × 5 feet. Carried over on piers of Head Regulator of Phul Feeder, 4 spans of 20 feet. Extra cost of Aqueduct being taken the same as that of Bhadaur Distributary crossing Abohar-Bhatinda Feeder—		
	Cost for abutment and half arch, 2 No. at Rs. 3,529 each ...	Rs. 7,058	
	Cost for pier and 1 span, 3 No. at Rs. 1,600 each ...	4,800	
	Total cost for Aqueduct ...	11,858	
	Total cost of Head Regulator including cost of Aqueduct ...	73,671	
	Balance of Head Regulator taken under D.—Regulators ...	61,813	
	Cost of Aqueduct chargeable to this sub-head ...	11,858	
	Constructing new Head for <i>Mari Minor</i> from head of Phul Distributary above Balloki Fall, mile 55.4, Bhatinda Branch, parallel with the branch in existing canal land and across the Aqueduct combined with the Head Regulator of Phul Feeder, to existing head of <i>Mari Minor</i> mile 60. 4.6 miles at Rs. 3,000 per mile ...	13,800	
	Add for <i>Minor</i> from <i>Mari Minor</i> parallel to Phul Feeder to take up tail of Chotia <i>Minor</i> . 3 miles at Rs. 2,000 per mile ...	6,000	
	Total ...	31,658	
4,100	Aqueduct for Phul Distributary R. D. 47,135 feet, discharge 85 cusecs, steel trough 5 feet × 5 feet. Carried over on piers of V. R. Bridge, 4 spans of 24 feet. The existing full supply of the Phul Distributary at R. D. 47,135 feet, where it will cross the Phul Feeder, is 163 cusecs. The lower reach of the Phul Distributary will be fed from a new head at the tail of the Phul Feeder, leaving only the Mehraj Branch and the water-courses between that point and R. D. 47,135 to be supplied by the Aqueduct across the Phul Feeder. The discharge required under existing conditions is 65 cusecs, to increase the intensity to 40 per cent, about 20 cusecs more will be required, i.e., 85 cusecs in all. An Aqueduct 5 feet × 5 feet running 4 feet deep water-way 20 sq. feet will require a velocity of 4.2 feet per second which will be easily obtainable as there will be a Fall downstream of the Aqueduct. The extra cost of the Aqueduct is taken the same as that of Bhadaur Distributary crossing Abohar-Bhatinda Feeder.		
	Carried over	31,658	1,43,888

G. 1.—CANAL CROSSINGS—CONTINUED.

R. D. Mile. Feet.		Amount. Rs.	Total. Rs.
	PHUL FEEDER—CONCLUDED.		
	Brought forward ...	31,658	1,48,888
	Cost of Aqueduct. Abutment and half arch, 2 No. at Rs. 3,529 each ...	Rs. 7,058	
	Pier and 1 span, 3 No. at Rs. 1,600 each ...	4,800	
	Cost of V. R. Bridge as per Statement of G. Bridges ...	18,190	
	Total cost of V. R. Bridge and Aqueduct ...	30,048	
	Deduct cost of V. R. Bridge taken under G. Bridges ...	18,190	
	Extra cost of Aqueduct chargeable to this sub-head ...	11,858	
	Remodelling Phul Distributary: 1'62 feet rise in bed and full supply from Fall at R. D. 35,715 to Fall at R. D. 45,876, and 3'23 feet rise in bed and full supply from Fall at R. D. 45,876 to Crossing—		
	Raising banks of Distributary for 2 miles at Rs. 2,000 per mile ...	Rs. 4,000	
	Raising 1 No. Bridge at Rs. 1,000 each ...	1,000	
	Constructing new Fall below Crossing, 1 No. at Rs. 2,500 ..	2,500	
	Total cost of remodelling ...	7,500	
	Cost of Aqueduct ...	11,858	
	Total cost chargeable to this sub-head ...	19,358	
6	1,000		
	New Head Reach for Phul Distributary taking out from tail of Phul Feeder running parallel to Bhatinda-Bikaner Feeder to connect to the existing channel below the Fall at mile 14.5. Capacity 120 cusecs— Length 5 miles at Rs. 5,000 per mile ...	25,000	76,160
	RORI (A-9) FEEDER.		
0	0		
	Aqueduct for Bhundar Minor of Phul Distributary, R. D. mile 2—4,500, existing discharge 9 cusecs. Steel trough 5 feet × 5 feet.		
	Carried over on piers of Head Regulator of Rori (A-9) Feeder 2 spans of 20 feet. Extra cost of Aqueduct being taken the same as that of Bhadaur Distributary crossing Abohar- Bhatinda Feeder—		
	Cost of abutment and half arch, 2 No. at Rs. 3,529 each ...	7,058	
	Cost of pier and 1 span, 1 No. at Rs. 1,600 each ...	1,600	
	Total extra cost of Aqueduct ...	8,658	
	Total cost of Head Regulator including cost of Aqueduct ...	48,117	
	Balance of cost of Head Regulator taken under D. Regulators ...	39,459	
	Cost of Aqueduct chargeable to this sub-head ...	8,658	
Carried over ...		...	2,10,004

G. 1.—CANAL CROSSINGS—CONTINUED.

R. D. Mile. Feet.		RORI (A. 9) FEEDER—CONTINUED.	Amount. Rs.	Total. Rs.
		Brought forward ...	...	2,19,904
		Constructing new Head Reach for Bhundar Minor, from where Phul Distributary crosses Phul Feeder, to the Head Regulator of Rori Feeder, across which it is taken in an Aqueduct, and thence parallel to Rori Feeder to meet the original alignment. Rs.		
		2½ miles at Rs. 3,000 a mile ...	7,500	
		Add for Bridge at Railway Crossing ...	5,000	
		Constructing a Minor from below Aqueduct, parallel to Bhatinda-Bikaner Feeder, to take up high level irrigation of Phul Distributary below the Feeders, which will not be commanded by the new reach of the Phul Distributary taking out of the tail of the Phul Feeder.		
		2 miles at Rs. 2,000 a mile ...	4,000	
		Total ...	25,158	
5	3,760	Syphon for Mandi Distributary, R. D. mile 15—1,580 feet, discharge 25 cusecs. 1 steel tube 5 feet diameter—		
		Same as for Sandohn Branch at mile 19—200 feet ...	7,425	
		No change in the Distributary necessary.		
14	300	Syphon for Ghuman Distributary, R. D. mile 14—74 feet, discharge 28 cusecs. 1 Steel Tube 5 feet diameter—		
		Same as for Sandohn Branch at mile 19—200 feet ...	7,425	
		No change in the Distributary necessary.		
16	4,530	Aqueduct for Maur Branch of Ghuman Distributary, R. D. mile 7—3,300 feet, discharge 8 cusecs; steel trough 3 feet x 3 feet. Carried over on piers of V. R. Bridge 2 spans of 24 feet.		
		Designed and estimated in detail—		
		Cost of abutment and half arch, 2 No. at Rs. 2,618 each ...	5,236	
		Cost of pier and 1 span, 1 No. at Rs. 1,057 each ...	1,057	
		Cost of V. R. Bridge as per Statement of G. Bridges ...	12,380	
		Total cost of V. R. Bridge and Aqueduct ...	18,673	
		Deduct cost of V. R. Bridge taken under G. Bridges ...	12,380	
		Cost of Aqueduct chargeable to this sub-head ...	6,293	
		No change in the Maur Branch necessary.		
17	523	Syphon for Kotla Branch, R. D. mile 67—3,526 feet, discharge 517 cusecs, 3 barrels of 8 feet diameter, as detailed estimate		
		No change in Kotla Branch necessary.	43,414	
		Carried over ...	99,715	2,19,904

G. 1.—CANAL CROSSINGS—CONTINUED.

R. D. Mile. Feet.		Amount. Rs.	Total. Rs.
	RORI (A-9) FEEDER—CONCLUDED.		
	Brought forward ...	89,715	2,19,904
19 200	Syphon for <i>Sandoha Branch</i> of Bheni Distributary, R. D. mile 4—3,322 feet, discharge 50 cusecs. 1 steel pipe of 5 feet diameter, as detailed estimate ... No change in Sandoha Branch necessary.	7,425	
24 600	Syphon for <i>Jaga Branch</i> of Bheni Distributary, R. D. mile 7—3,493 feet, discharge 28 cusecs. 1 steel pipe of 5 feet diameter— Same as for Sandoha Branch at mile 19—200 feet ... No change in Jaga Branch necessary.	7,425	
82 250	Syphon for <i>Musha Branch</i> of Bhiki Distributary, R. D. mile 26—2,464 feet, discharge 20 cusecs. 1 steel pipe of 5 feet diameter— Same as for Sandoha Branch at mile 19—200 feet ... No change in Musha Branch necessary.	7,425	1,11,990
	BHATINDA BIKANER FEEDER.		
23 4,000	Aqueduct for <i>Mehta Branch</i> of Bhatinda Distributary, R. D. 21,250, discharge 25 cusecs. Steel trough 5 feet x 5 feet. Carried over on piers of V. R. Bridge, 3 span of 20 feet. Designed and estimated in detail— Cost for abutment and half arch, 2 No. Rs. at Rs. 2,775 each ... 5,550 Cost for pier and 1 span, 2 No. at Rs. 1,408 each ... 2,816 Cost of V. R. Bridge as per Statement of G. Bridges ... 13,200 Total cost of V. R. Bridge and Aqueduct ... 21,566 Deduct cost of V. R. Bridge taken under G. Bridges ... 13,200 Cost of Aqueduct chargeable to this sub-head 8,366 No change in Mehta Branch necessary.	8,366	8,366
	ABOJAR BRANCH ALTERATIONS.		
	<i>Bhowani Wadni Feeder.</i> —New channel parallel to Abohar Branch, 213,900 feet or 42·8 miles, say 43 miles long. This channel will be made within the existing canal land, hence rate of Rs. 5,000 per mile is proposed, 43 miles of channel at Rs. 5,000 per mile ... 2,15,000 55,17,040 sq. feet of lining at Rs. 15 per cent. ... 8,27,556 Total ... 10,42,556		
	Carried over ...	10,42,556	3,40,260

G. 1.—CANAL CROSSINGS—CONCLUDED.

R. D. Mile. Feet.		Amount. Rs.	Total. Rs.
	ABOHAR BRANCH ALTERATIONS—CONCLUDED.		
	Brought forward ...	10,42,556	3,40,260
	Cost of Aqueduct across Falls on Abohar Branch to feed right bank Distributaries—		
	Khanpur Distributary. { 3 spans of 25 feet each. { 1 span of 26 " " "Lock."		
	Chupki " { 3 spans of 25 " each. { 1 span of 26 " " "Lock."		
	Ballowal " { 3 spans of 25 " each. { 1 span of 26 " " "Lock."		
	Jassowal " { 3 spans of 24 " each. { 1 span of 26 " " "Lock."		
	Jagraon " { 3 spans of 22 " each. { 1 span of 26 " " "Lock."		
	Dangian Minor { 3 spans of 21 " each. { 1 span of 26 " " "Lock."		
	Total 24		
	Cost for Phul Distributary Crossing of Bhatinda-Bikaner, Feeder at Balloki, estimated under Bhatinda Branch alterations for 2 spans, is Rs. 8,658.		
	Therefore cost is for these crossing will be 24 spans at Rs. 4,329 per span ... 1,03,896	1,03,896	
	Total cost ...	...	11,46,452
	BHATINDA BRANCH ALTERATIONS.		
	The Phul Distributary at present takes off above the Balloki Fall of Bhatinda Branch at mile 55—2,000 feet. Instead of running a supply of 173 cusecs for the Phul Distributary from the Tallewal Fall at mile 44—1,750 feet to Balloki Fall in the Branch with a capacity of 1,275 cusecs, the Phul Distributary will be supplied by enlarging the capacity of the Dhipali Distributary which runs for 6½ miles along the branch and constructing a new length of 4½ miles to Balloki Fall and then carrying it across the 2 No. 23 feet spans of the Fall in an Aqueduct—		
	Increasing capacity of Dhipali Distributary from 97 cusecs to 271 cusecs for 6½ miles at Rs. 4,000 per mile ...	26,000	
	New length of Distributary, 4½ miles at Rs. 5,000 per mile ...	22,500	
	Aqueduct at Balloki Fall, 2 spans of 23 feet, say same cost as Aqueduct across Rori (A.-9) Feeder Head Regulator ...	8,658	57,158
	GRAND TOTAL G. 1.—CANAL CROSSINGS ...	...	15,43,870

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

J.—MILLS.

R. Mile.	D. Feet.		Amount. Rs.	Total. Rs.
RORI (A-9) FEEDER.				
34	2,000	7 feet Fall at tail through Regulator into Bara Gudah Distributary, say mill of 5 stones at Rs. 2,000 each...	10,000	20,000
		About 6 feet Fall, mile 20 of Bara Gudah Distributary below Bhatinda-Sirsa Railway, say mill of 5 stones at Rs. 2,000 each ...	10,000	
BHATINDA-BIKANER FEEDER.				
5	300	8.5 feet Fall near Lehra Mohabat Railway Station on Bhatinda Dhuri Line, 2,300 cusecs full supply— H. P. available $\frac{2,300 \times 8.5}{10} = 1,955$. Say 10 stones at Rs. 3,000 ...	30,000	60,000
22	2,000	9 feet Fall near Bhatinda on Bhatinda-Sirsa Railway Conditions as above— 10 stones at Rs. 3,000 ...	30,000	
BIKANER BRANCHES.				
BORDER BRANCH.				
0	0	7 feet Fall in water surface through Regulator near Dabwali Mandi and Railway Station on Jodhpur-Bikaner Railway— Discharge 518 cusecs, H. P. 362. Say lump sum ...	15,000	30,000
		Note.—There is a Fall into the Main Branch into which the Turbines could tail in rotational working.		
MAIN BRANCH.				
32	3,000	9 feet Fall near Hanumangarh on Jodhpur-Bikaner Railway— Discharge 287 cusecs, H. P. 258. Say lump sum ...	15,000	30,000
		Note.—The 9 feet Fall is in water surface which is more than the fall in bed in this case.		
GRAND TOTAL J.—MILLS				1,10,000

SUTLEJ DAM
LOWER SIR
K-BUILD

Serial No. of Item	Description of Buildings.	Names of Buildings.	Rate per unit.	HEAD WORKS.				NEW MAIN LINE.				ABOHAR-BHATINDA FEEDER.					
				Ludhiana and Ferozepore.	Alival.	Total number of Buildings	Total cost of Buildings, Head-works.	Sidwan.	Ajitwal.	Total number of Buildings.	Total cost of Buildings on new Main Line.	Dandhar.	Takhtupura.	Bhadaur.	Total number of Buildings.	Total cost of Buildings on Abohar-Bhatinda Feeder.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
1	Permanent	Superintending Engineer's residence.	18,000	1	...	1	18,000	...	...	...	...	...	...	...	...	Rs.
2	Do.	Superintending Engineer's office	20,000	1	...	1	20,000	...	...	...	...	...	...	...	...	...
3	Do.	Do. menials	5,000	1	...	1	5,000	...	...	...	...	...	...	...	...	...
4	Do.	Do. godown	2,000	1	...	1	2,000	...	...	...	...	...	...	...	...	...
5	Do.	Executive Engineer's bungalow	15,000	1	...	1	15,000	...	...	...	...	...	...	...	...	...
6	Temporary	Ditto ditto	8,000	...	...	...	...	...	...	...	...	...	...	...	...	...
7	Permanent	Sub-Divisional Officer's bungalow	11,000	...	1	1	11,000	...	...	...	...	...	...	...	...	...
8	Temporary	Ditto ditto	6,000	...	2	2	12,000	...	1	1	6,000	...	1	...	1	6,000	
9	Permanent	Divisional Office ...	18,000	1	...	1	18,000	...	...	...	...	...	...	...	...	...
10	Temporary	Ditto	12,000	...	...	...	...	...	...	...	...	...	...	...	...	...
11	Permanent	Sub-Divisional Office	2,000	...	1	1	2,000	...	...	...	...	...	...	...	...	...
12	Temporary	Ditto	1,000	...	2	2	2,000	...	1	1	1,000	...	1	...	1	1,000	
13	Permanent	Telegraph Office and Signaller's quarters, single.	2,000	...	...	1	...	1	1	2	4,000	...	1	...	1	2,000
14	Do.	Ditto ditto double	3,500	...	1	1	3,500	...	...	...	...	1	...	...	1	3,500
15	Do.	Sub-Assistant Surgeon's quarters and dispensary.	4,000	...	1	1	4,000	...	...	...	...	...	...	...	...	...
16	Temporary	Ditto ditto	2,000	...	...	...	...	...	...	...	...	...	...	...	...	...
17	Permanent	Rest-house and out-houses 1st, double.	18,000	...	1	1	18,000	...	...	...	...	...	...	...	...	...
18	Do.	Rest-house and out-houses 1st, single.	13,500	...	...	...	...	1	1	2	27,000	...	...	...	...	...
19	Do.	Subordinate rest-house ...	2,500	...	1	1	2,500	1	1	2	5,000	...	...	...	...	...
20	Do.	Enlarging existing rest-houses ...	8,000	...	...	...	...	...	...	...	...	1	1	1	3	2,400
21	Do.	Barkandaz quarters	2,000	1	1	2	4,000	...	...	...	...	...	...	...	...	...
22	Temporary	Ditto	1,250	...	...	...	...	...	1	1	1,250	...	1	...	1	1,250
23	Permanent	Menial quarters for Divisional Office.	2,500	1	...	1	2,500	...	...	...	...	...	...	...	...	...
24	Temporary	Ditto ditto	1,500	...	...	...	...	...	...	...	...	...	...	...	...	...
25	Permanent	Menial quarters for Sub-Division	1,500	...	1	1	1,500	...	...	...	...	...	...	...	...	...
26	Temporary	Ditto ditto	1,000	...	2	2	2,000	...	1	1	1,000	...	1	...	1	1,000	
27	Permanent	Upper Subordinates' quarters ...	3,000	...	1	1	3,000	...	...	...	...	...	...	...	...	...
28	Temporary	Ditto ditto	1,750	...	2	2	3,500	...	...	...	...	...	1	...	1	1,750
29	Permanent	Lower Subordinates and Clerks' quarters (per unit).	1,500	...	4	4	6,000	1	...	1	1,500	1	...	...	1	1,500
30	Temporary	Ditto ditto	1,000	...	6	6	6,000	...	6	6	6,000	1	2	1	4	4,000	
31	Permanent	Mistries lines and menials (per unit).	400	...	10	10	4,000	...	...	...	...	...	...	...	...	...
32	Temporary	Ditto ditto	250	...	10	10	2,500	...	20	20	5,000	...	4	2	6	1,500	
33	Permanent	Regulating Establishment and huts.	20,000	...	1	1	20,000	...	...	...	...	...	...	...	...	...
34	Do.	Regulating Establishment and huts at other Regulators.	2,500	...	...	...	...	1	...	1	2,500	1	...	...	1	2,500
35	Do.	Storeyard, Workshops and Engine-sheds	20,000	...	1	1	20,000	...	1/5	1/5	4,000	...	1/10	...	1/10	2,000	
36	Do.	Lime, cement store (unit)	3,000	...	4	4	12,000	...	1	1	3,000	1	1	...	2	6,000	
37	Do.	Gauge reader's huts	500	...	...	...	...	...	...	...	...	...	...	...	...	...
38	Do.	Zilladars' houses, Munshi's Office and Peon.	4,500	...	...	...	...	...	...	...	...	...	...	...	...	...
Total cost of Permanent Buildings							1,92,000					50,000					41,500
Total cost of Temporary Buildings							27,000					19,250					16,500
GRAND TOTAL OF COST OF BOTH PERMANENT AND TEMPORARY BUILDINGS							2,19,000					69,250					58,000

8,58,750		
Grand Total	...	20,13,000
Deduct Head-works	...	2,19,000
Total Main Canal and Branches	...	17,94,000

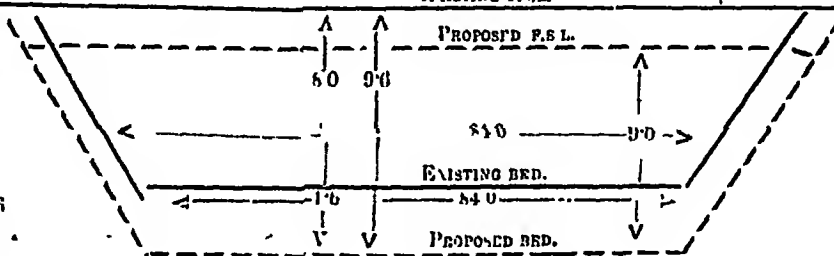
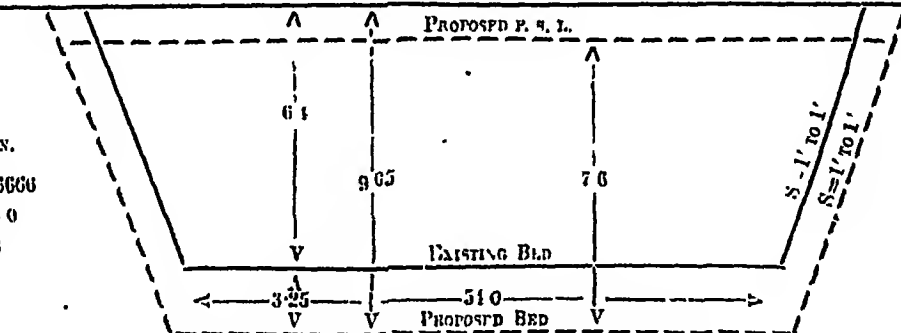
LOWER SIRHIND CANAL.

Serial No.	R. D.	EARTHWORK.		Total.	Rate per % c.ft.	Amount	Total Cost.
		Digging.	Borrow-pits.				
MAIN LINE UPPER.							
1	Mile. Feet. 0 0 to 8 4,000	C. ft. 75,515,900	C. ft. 2,445,650	C. ft. 77,961,550	Rs. 10	Rs. 7,79,616	Rs. 7,79,616
GREY CANAL FEEDER.							
1	0 0 to 10 0	22,081,200	1,762,700	23,843,900	8	1,90,751	2,74,509
2	10 0 to 28 2,000	10,574,900	3,374,700	13,959,600	6	83,758	
				37,803,500			
MAIN LINE LOWER.							
1	8 4,000 to 27 3,000	239,480,300	Nil	239,480,300	10	23,94,803	23 94.803
ABOHAR-BHATINDA FEEDER.							
1	0 0 to 25 0	130,794,800	198,600	130,993,400	8	10,47,947	10,47,947
PHUL FEEDER.							
1	0 0 to 6 1,000	22,595,950	358,050	22,954,000	7	1,60,678	1,60,678
RORI (A-9) FEEDER.							
1	0 0 to 28 4,000	54,446,200	12,157,150	66,603,350			
2	28 4,000 to 34 2,000	3,298,650	9,676,350	12,975,000			
	Total	79,578,350	6	4,77,470	4,77,470
						ried over ...	51,35,023

Serial No.	R. D.	EARTHWORK.		Total.	Rate per % c.ft.	Amount.	Total Cost.
		Digging.	Borrow-pits.				
Brought forward ...							Rs. 51,35,023
BHATINDA-BIKANER FEEDER.							
	Mile. Feet.	C. ft.	C. ft.	C. ft.	Rs.	Rs.	
1	0 0 } to 4,000 }	17,061,200	1,336,050	18,397,250			
2	5 4,000 } to 15 0 }	20,996,000	4,722,300	25,718,300			
3	15 0 } to 22 2,000 }	13,067,300	4,309,850	17,377,150			
4	22 2,000 } to 46 1,000 }	51,238,450	7,941,050	59,179,500			
	Total	120,672,200	7	8,44,708	8,44,705
BIKANER BRANCHES.							
MAIN BRANCH.							
1	0 0 } to 9 0 }	8,409,000	7,078,700	15,487,700			
2	9 0 } to 18 0 }	5,988,650	15,077,450	21,066,100			
3	18 0 } to 24 0 }	4,162,150	4,603,850	8,766,000			
4	24 0 } to 27 0 }	1,069,650	5,225,500	6,295,150			
5	27 0 } to 32 3,000 }	4,566,050	2,896,600	7,462,650			
6	32 3,000 } to 43 0 }	4,510,200	6,214,800	10,725,000			
7	43 0 } to 47 2,000 }	1,451,550	2,681,100	4,132,650			
8	47 2,000 } to 53 0 }	1,647,400	3,412,800	5,060,200			
	Total	78,995,450	6	4,78,973	
Carried over ...							59,79,728.

Serial No.	R. D.	EARTHWORK.		Total.	Rate per % c.ft.	Amount.	Total Cost.
		Digging.	Borrow pits.				
Brought forward ..							Rs. 59,79,728
BORDER BRANCH.							
	Mile. Feet.	C. ft.	C. ft.	C. ft.	Rs.	Rs.	
1	0 0 } to 1 3,000 }	1,567,350	Nil.	1,567,350			
2	1 3,000 } to 8 4,000 }	3,032,450	5,553,950	8,586,400			
	Total ...	...	...	10,153,750	6	60,923	
	Bikaner Main Branch.	...	...	...	...	4,73,973	
	Bikaner Border Branch.	...	...	...	...	60,923	
							5,34,896
ABOHAR BRANCH ALTERATIONS.							
42	3,000	Lowering and widening bed of Abohar Branch from Daudhar Fall to					
	to	Head Sutlej Navigation Channel. Length 27,635 feet.					
48	635						
EXISTING F.S.L.							
<p>NEW CONDITION BED SLOPE=1/6666 BED WIDTH=100'0 F.S DEPTH=9'0'</p>							
<p>Mean Lowering $\frac{(734.32 - 732.27) + (29.9 - 28.24)}{2}$ $= \frac{2.05 + 1.66}{2} = \frac{3.71}{2} = 1.86$ say 2'0 feet.</p>							
<p>Volume to be excavated $\{(100 + 10) 10 - (80 + 8) 8\} 27,635$ $= (1,100 - 704) \times 276.35 = 396 \times 276.35$ $= 1,09,43,460$ say 1,09,43,500 c. ft.</p>							
Carried over							65,14,624

L.—EARTHWORK—CONCLUDED.

R. D. Miles. Feet.		Amount. Rs. ...	Total. Rs. 65,14,624
	Brought forward	...	
	ABOHAR BRANCH ALTERATIONS.—CONTINUED.		
48 635 to 50 4,000	Lowering bed of Abohar Branch from Head Sutlej Navigation Channel to 8 feet Fall and Bridge at Gholia, length 13,365 feet. Mean lowering $\frac{(729.9 - 28.24) + (727.76 - 726.24)}{2}$ $= \frac{1.6 + 1.52}{2} = 1.56$ say 16. EXISTING F.S.L.		
	 <p>NEW CONDITION. BED SLOPE = 1/6666 BED WIDTH = 84.0 F. S. DEPTH = 9.0</p> <p>Volume to be excavated = $\left\{ (84 \times 1.6) + \left(9.6^2 - 8.0^2 \right) \right\} \times 13,365$ $= \left\{ 134.4 + (92.16 - 64) \right\} \times 13,365$ $= (134.4 - 28.16) \times 13,365$ $= 168.56 \times 13,365 = 21,72,614$ say 21,73,000. R.D. M. 42-3,000 ft. to R.D. M. 48-635 ft. = 1,00,43,500 c. ft. R.D. M. 48-635 ft. to R.D. M. 50-4,000 ft. = 21,73,000 c. ft. Total ... 1,31,16,500 c. ft. ABSTRACT. 13,116,500 c. ft. earthwork at Rs. 6 per thousand = 78,699 Contingencies at Rs. 5 per cent. = 3,935</p>		82,634
	BHATINDA BRANCH ALTERATIONS.		
58 2,650 to 61 2,000	Lowering bed of Bhatinda Branch from R. D. 292,650 feet, Dhipali, to Sadhana Fall, R. D. 307,000 feet, length 14,350 feet. EXISTING F. S. I.  <p>NEW CONDITION. BED SLOPE = 1/6666 BED WIDTH = 54.0 F. S. DEPTH = 7.0</p> <p>Mean lowering = $\frac{(713.74 - 710.60) + (716.10 - 712.75)}{2}$ $= \frac{3.14 + 3.35}{2} = 3.25.$ Volume to be excavated $\left\{ 54 \times 3.25 + (9.65^2 - 6.4^2) \right\} \times 14,350$ $= \left\{ 175.5 - (93.0 - 41.0) \right\} \times 14,350$ $= (175.5 - 52) \times 14,350$ $= 227.5 \times 14,350 = 3,264,625$ c. ft. say 3,265,000 c. ft. ABSTRACT. 3,265,000 c. ft. earthwork at Rs. 6 per thousand = 19,590 Contingencies at Rs. 5 per cent. = 980</p>		20,570
	GRAND TOTAL L.—EARTHWORK	...	66,17,828

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

L 1.—LINING.

R. D.	Length.	Perimeter.	Area sq. ft.	Rate % sq. ft.	Amount.	Total.
1	2	3	4	5	6	7
Mile Feet.	MAIN LINE UPPER.				Rs.	Rs.
0 0 to 8 4,000 }	44,000	215	9,460,000	20	18,92,000	18,92,000
	MAIN LINE LOWER.					
8 4,000 to 27 3,000 }	94,000	194	18,236,000	20	36,47,200	36,47,200
	ABOHAR-BHATINDA FEEDER.					
0 0 to 25 0 }	125,000	140.2	17,525,000	20	35,05,000	35,05,000
	PHUL FEEDER.					
0 0 to 6 1,000 }	31,000	113.2	3,509,200	20	7,01,840	7,01,840
	RORI (A-9) FEEDER.					
0 0 to 23 4,000 }	144,000	63.4	9,129,600			
34 3,000 }	28,000	48.6	1,360,800			
Total ...	...	...	10,490,400	20	20,98,080	20,98,080
	BHATINDA-BIKANER FEEDER.					
0 0 to 46 1,000 }	231,000	77.4	17,879,400	20	35,75,880	35,75,880
Carried over ...						1,54,20,000

L. 1.—LINING—CONCLUDED.

R. D.	Length.	Perimeter.	Area sq. ft.	Rate % sq. ft.	Amount.	Total.
1	2	3	4	5	6	7
Brought forward ...					Rs. ...	Rs. 1,54,20,000
BIKANER BRANCHES.						
BIKANER MAIN BRANCH.						
0 0	45,000	61·4	2,763,000			
to 9 0						
to 18 0	45,000	60·4	271,800			
to 24 0	30,000	47·6	1,428,000			
to 27 0	15,000	47·0	705,000			
to 32 3,000	28,000	46·0	1,288,000			
to 43 0	52,000	30·0	1,560,000			
to 53 0	50,000	29·0	1,450,000			
Total ...	...	...	11,912,000	20	23,82,400	
BIKANER BORDER BRANCH.						
0 0 } to 8 4,000 }	44,000	37·8	1,663,200	20	3,32,640	27,15,040
GRAND TOTAL OF L. 1.—LINING					...	1,81,35,040

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

M.—PLANTATION.

MAIN LINE UPPER.				Amount. Rs.	Total. Rs.
Avenue 46 miles at Rs. 100 per mile				4,600	
Mile 0-4 four lines = 16 miles.					
Miles 4-9 six lines = 30 miles.					
Total 46 miles.					
Plantation on spoil, 172 acres at Rs. 25 per acre				4,300	8,900
Miles 4-9 spoil width 2 x 150 ft.					
GREY CANAL FEEDER.					
Avenue 36 miles one line only at Rs. 100 per mile				3,600	
Plantation on spoil, 100 acres at Rs. 25 per acre				2,500	6,100
MAIN LINE LOWER.					
Avenue 111 miles at Rs. 100 per mile				11,100	
Mile 9 to 27½ six lines.					
Plantation on spoil, 637 acres at Rs. 25 per acre				15,925	
Mile 9 to 27½ spoil width 2 x 150 ft.					
Rest House compound at Sidhwan, one at Rs. 500 each				500	
Canal Station at Ajitwal. Lump sum				2,500	30,025
ABOHAR BHATINDA FEEDER.					
Avenue 130 miles at Rs. 100 per mile				13,000	
15 miles six lines = 90 miles.					
10 miles four lines = 40 miles.					
130 miles.					
Plantation on spoil, 172 acres at Rs. 25 per acre				4,300	17,300
15 miles spoil width 2 x 50 ft.					
PHUL FEEDER.					
Avenue 35 miles at Rs. 100 per mile				3,500	
5 miles six lines = 30 miles.					
12 miles four lines = 48 miles.					
say 35 miles					
Plantation on spoil 35 acres at Rs. 25 per acre				875	
5 miles spoil width 2 x 30 ft.					
Canal Station at Rampura Phul. Lump sum				2,500	6,875
Carried over					69,200

M.—PLANTATIONS—CONCLUDED.

	Amount. Rs.	Total. Rs.
Brought forward ...	...	69,200
RORI (A-9) FEEDER.		
Avenue 137 miles at Rs. 100 per mile ... 34.4 miles four lines = 137 miles.	13,700	
Plantation on spoil, 70 acres at Rs. 25 per acre ... 12 miles spoil width 2 × 25 feet.	1,750	
Compounds of Rest-houses on Branch and Distributaries 22 No. at Rs. 500 each ...	11,000	
Canal Station at Sirsa. Lump sum ...	2,500	28,950
BIATINDA-BIKANER FEEDER.		
Avenue 184 miles at Rs. 100 per mile ... 46 miles four lines = 184 miles.	18,400	
Plantation on spoil, 115 acres at Rs. 25 per acre ... 20 miles width 2 × 25 feet.	2,875	
Compounds of Rest-houses No. 4 at Rs. 500 each ...	2,000	23,275
BIKANER BRANCHES.		
Avenue 124 miles at Rs. 100 per mile ... 61.8 miles two lines = 124 miles.	12,400	
Plantation on spoil, 80 acres at Rs. 25 per acre ...	2,000	
Hanumangarh Canal Station. Lump sum ...	5,000	
Compounds of Rest-houses on Branches and Distributaries 36 No. at Rs. 500 each ...	18,000	37,400
GRAND TOTAL OF M.—PLANTATIONS ...		1,58,825

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

O.—MISCELLANEOUS.

	Amount. Rs.	Total. Rs.
MAIN LINE UPPER.		
Boundary Pillars 9 miles at every 500 feet and 10 per cent. for curves at Rs. 6 each, Rs. 120 per mile	1,080	
Distance Marks 9 miles at every 1,000 feet both banks at Rs. 20 each, Rs. 200 per mile	1,800	
Experiments. Lump sum	5,000	
Conservancy. Do.	4,500	
Bench Marks embedded every 10,000 feet 5 No. at Rs. 50 each	250	
Drainage of banks and spoil 9 miles at every 1,000 feet each bank at Rs. 120 each, Rs. 1,200 per mile	10,800	23,430
GREY CANAL FEEDER.		
Boundary Pillars 36 miles at every 500 feet and 10 per cent. for curves at Rs. 6 each, Rs. 120 per mile	4,320	
Distance Marks 36 miles at every 1,000 feet one bank at Rs. 20 each, Rs. 100 per mile	3,600	
Bench Marks embedded every 10,000 feet 9 No. at Rs. 50 each	900	
Drainage of banks and spoil 36 miles at every 1,000 feet each bank at Rs. 70 each, Rs. 700 per mile	25,200	34,020
MAIN LINE LOWER.		
Boundary Pillars 18½ miles at every 500 feet and 10 per cent. for curves at Rs. 6 each, Rs. 120 per mile	2,220	
Distance Marks 18½ miles at every 1,000 feet both banks at Rs. 20 each, Rs. 200 per mile	3,700	
Experiments. Lump sum	10,000	
Conservancy. Do.	9,000	
Bench Marks embedded every 10,000 feet 9 No. at Rs. 50 each	450	
Well surveys and fixing Plates in wells in tract not yet under observation. Lump sum	1,500	
Fencing Rest-houses compounds 2 No. at Rs. 300 each	600	
Fencing Canal station at Ajitwal. Lump sum	3,000	
Unforeseen. Do.	5,000	
Drainage of banks and spoil 18½ miles at every 1,000 feet each bank at Rs. 120 each, Rs. 1,200 per mile	22,200	57,670
ABOHAR-BHATINDA FEEDER.		
Boundary Pillars 25 miles at every 500 feet and 10 per cent. for curves at Rs. 6 each, Rs. 120 per mile	3,000	
Distance Marks 25 miles at every 1,000 feet both banks at Rs. 20 each, Rs. 200 per mile	5,000	
Experiments. Lump sum	15,000	
Conservancy. Do.	12,000	
Bench Marks embedded every 10,000 feet 12 No. at Rs. 50 each	600	
Fencing Rest-houses compounds 3 No. at Rs. 300 each	900	
Unforeseen. Lump sum	5,000	
Drainage of banks and spoil 25 miles at every 1,000 feet each bank at Rs. 110 each, Rs. 1,100 per mile	27,500	69,000
PHUL FEEDER.		
Boundary Pillars 6½ miles at every 500 feet and 10 per cent. for curves at Rs. 6 each, Rs. 120 per mile	744	
Distance Marks 6½ miles at every 1,000 feet both banks at Rs. 20 each, Rs. 200 per mile	1,240	
Experiments. Lump sum	3,000	
Conservancy. Do.	2,500	
Bench Marks embedded every 10,000 feet 3 No. at Rs. 50 each	150	
Fencing canal station at Rampura Phul. Lump sum	3,000	
Unforeseen. Do.	1,000	
Drainage of banks and spoil 6½ miles at every 1,000 feet each bank at Rs. 110 each, Rs. 1,100 per mile	6,820	18,454
Carried over		2,02,574

O.—MISCELLANEOUS—CONCLUDED.

	Amount. Rs.	Total. Rs.
Brought forward ...	...	2,02,574
RORI (A-9) FEEDER.		
Boundary Pillars 34.4 miles at every 500 feet and 10 per cent. for curves at Rs. 6 each, Rs. 120 per mile ...	4,128	
Distance Marks 34.4 at every 1,000 feet on one bank only at Rs. 20 each, Rs. 100 per mile ...	3,440	
Experiments. Lump sum ...	8,000	
Conservancy. Do. ...	5,000	
Bench Marks embedded every 10,000 feet 17 No. at Rs. 50 each ...	850	
Fencing Rest-house compounds 22 No. at Rs. 300 each ...	6,600	
Fencing canal station at Maur. Lump sum ...	2,000	
Unforeseen. Do. ...	5,000	
Drainage of banks and spoil 34.4 miles at every 1,000 feet each bank at Rs. 100 each, Rs. 1,000 per mile ...	34,400	69,418
BIKANER-BHATINDA FEEDER.		
Boundary Pillars 46 miles at every 500 feet and 10 per cent. for curves at Rs. 6 each, Rs. 120 per mile ...	5,520	
Distance Marks 46 miles at every 1,000 feet one bank only at Rs. 20 each, Rs. 100 per mile ...	4,600	
Experiments. Lump sum ...	10,000	
Conservancy. Do. ...	6,000	
Bench Marks embedded every 10,000 feet 23 No. at Rs. 50 each ...	1,150	
Fencing Rest-house compounds 4 No. at Rs. 300 each ...	1,200	
Unforeseen. Lump sum ...	5,000	
Drainage of banks and spoil 46 miles at every 1,000 feet each bank at Rs. 100 each, Rs. 1,000 per mile ...	46,000	79,470
BIKANER BRANCHES.		
Main Branch 53 miles } Border Branch 8.8 miles }	... Total 61.8 miles.	
Boundary Pillars 61.8 miles at every 500 feet and 10 per cent. for curves at Rs. 6 each, Rs. 120 per mile ...	7,416	
Distance Marks 61.8 miles at every 1,000 feet on one bank only at Rs. 20 each, Rs. 100 per mile ...	6,180	
Experiments. Lump sum ...	10,000	
Conservancy. Do. ...	6,000	
Bench Marks embedded every 10,000 feet 31 No. at Rs. 50 each ...	1,550	
Fencing Rest-house compounds 36 No. at Rs. 300 each ...	10,800	
Fencing canal station at Hanumangarh. Lump sum ...	5,000	
Unforeseen. Do. ...	5,000	51,946
GRAND TOTAL O.—MISCELLANEOUS		4,03,408

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

P.—MAINTENANCE.

The provision for P.—Maintenance in the Revised Project for the Triple Canal system is :—

	Rs.		
Upper Jhelum	... 6,72,560	2.48	} Per cent. on cost of Main Canal and Branches less cost of land.
Upper Chenab	... 4,89,361	3.28	
Lower Bari Doab	... 3,08,866	4.26	
		3	10.02
			3.34

	Rs
For Lower Sirhind Canal the total probable cost of works excluding land and without maintenance and special Tools and Plant will be ...	3,71,14,071
<i>Deduct</i> —cost of Lining which will need no maintenance and is responsible for the high work estimate ...	1,81,35,041
Balance ...	1,89,79,031
Take mean per cent. of Triple Project, say 3 per cent. . .	5,67,000
Say	6,00,000

The distribution by Branches is made as below :—

	Rs.
Main Line Upper	... 45,000
Grey Canal Feeder	... 75,000
Main Line Lower	... 97,500
Abohar-Bhatinda Feeder	... 1,05,000
Phul Feeder	... 37,500
Rori (A-9) Feeder	... 90,000
Bhatinda-Bikaner Feeder	... 90,000
Bikaner Branches	... 60,000
GRAND TOTAL P.—MAINTENANCE	... 6,00,000

Q.—LOSSES ON STOCK.

Losses on Stock cannot be estimated, an allowance of Rs. 50,000 is made.

The distribution by Branches is made as below :—

	Rs.
Main Line Upper	... 4,000
Grey Canal Feeder	... 6,000
Main Line Lower	... 8,000
Abohar-Bhatinda Feeder...	... 8,000
Phul Feeder	... 3,000
Rori (A-9) Feeder	... 8,000
Bhatinda-Bikaner Feeder...	... 8,000
Bikaner Branches	... 5,000
GRAND TOTAL Q.—LOSSES ON STOCK	... 50,000

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

(3).—DISTRIBUTARIES.

Aeres.		Rate. Rs.	Amount. Rs.	Total. Rs.
ABOHAR BRANCH ALTERATIONS.				
MUKTSAR HITHAR TRACT.				
80,000	Gross area within irrigation limits	3-0-0	2,40,000	
	Increasing the capacity of the Faridkote Distributary to carry the supply for this Tract. 20 miles at Rs. 2,000 per mile		40,000	2,80,000
RORI CHAUTALA (A.-9) TRACT.				
681,000	Gross area within Irrigation limits	3-0-0	20,43,001	2 0,43,000
BIKANER DISTRIBUTARIES.				
1,005,000	Gross area within Irrigation limits	2-12-0	27,63,750	27,63,750
GRAND TOTAL (3)—DISTRIBUTARIES ...				50,86,750

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

1. (5).—SPECIAL TOOLS AND PLANT.

	Amount. Rs.	Total. Rs.
MAIN LINE UPPER.		
<i>Railways—</i>		
<i>Ajitwal to Headworks.</i> —This 20 miles portion would have to be built in any case for the Headworks and the whole cost will be debited to Headworks.		
<i>Special Tools and Plant (Heavy)</i> — 10 per cent. of Total I (2), Main Canal and Branches, Rs. 35,64,163 ...	3,56,416	3,56,416
MAIN LINE LOWER.		
<i>Railways—</i>		
<i>Ajitwal to Headworks.</i> —This 20 miles portion would have to be built in any case for Headworks and the whole cost will be debited to Headworks.		
<i>Ajitwal to Daudhar</i> —8 miles— Cost of connection at Ajitwal Station, lump sum ...	Rs. 8,000	
Permanent-way laid, 8 miles at Rs. 30,000 per mile ...	2,40,000	2,48,000
<i>Special Tools and Plant (Heavy)</i> — 10 per cent. of Total I (2), Main Canal and Branches ...	7,48,582	9,96,582
ABOHAR-BHATINDA FEEDER.		
<i>Railways—</i>		
<i>Daudhar to Dhipali</i> —25 miles— Permanent-way laid, 25 miles at Rs. 30,000 per mile ...	7,50,000	
<i>Special Tools and Plant (Heavy)</i> — 10 per cent. of Total I (2), Main Canal and Branches ...	Rs. 5,92,651	13,42,651
PHUL FEEDER.		
<i>Railways—</i>		
<i>Rampura Phul to Dhipali</i> —7 miles— Cost of connection at Rampura Phul Station, lump sum ...	Rs. 8,000	
Permanent-way laid, 7 miles at Rs. 30,000 per mile ...	2,10,000	2,18,000
<i>Special Tools and Plant (Heavy)</i> — 10 per cent. of Total I (2), Main Canal and Branches ...	1,40,856	3,58,856
RORI (A.-9) FEEDER.		
<i>Railways—</i>		
<i>Rampura Phul to Maur</i> —16 miles— Cost of connection at Rampura Phul Station, lump sum ...	Rs. 8,000	
Permanent-way laid, 16 miles at Rs. 30,000 per mile ...	4,80,000	
<i>Maur to Tail of Rori A.-9 Feeder</i> —18 miles— Cost of connection at Maur Station, lump sum ...	8,000	
Permanent-way laid, 18 miles at Rs. 30,000 per mile ...	5,40,000	10,44,000
<i>Special Tools and Plant (Heavy)</i> — 10 per cent. of Total I (2), Main Canal and Branches ...	4,10,952	14,54,952
Carried over ...	...	45,09,457

I. (5).—SPECIAL TOOLS AND PLANT—CONCLUDED.

	Amonnt. Rs.	Total. Rs.
Brought forward ...	...	45,09,457
BHATINDA-BIKANER FEEDER.		
<i>Railways—</i>		
<i>Rampura Phul Railway Station to mile 20 crossing of Southern Punjab Railway ; mile 0—12 runs parallel to the Rajpura-Bhatinda Railway, leaving 8 miles from Bhuchu station to Southern Punjab Railway. 8 miles of permanent-way will suffice.</i>		
	Rs.	
Connection at Rampura Phul Station lump sum ...	8,000	
Two connections at Bhuchu station 2 at Rs. 8,000 each	16,000	
Permanent-way laid 8 miles at Rs. 30,000 per mile ...	2,40,000	
Lifting and relaying 12 miles at Rs. 5,000 per mile ...	60,000	3 24,000
<i>Sungat Station to Southern Punjab Railway, metre gauge, 11 miles—</i>		
Connection at Sungat, lump sum ...	4,000	
Permanent-way laid, 11 miles at Rs. 15,000 per mile ...	1,65,000	
<i>Sungat Station to Tail—15 miles. The 11 miles of permanent-way material can be lifted and relaid as sidings—</i>		
15 miles at Rs. 2,500 per mile ...	37,500	2,06,500
<i>Special Tools and Plant (Heavy)—</i>		
10 per cent. of Total 1 (2), Main Canal and Branches	58,97,235	5,89,723
BIKANER BRANCHES.		
<i>Railways—</i>		
<i>Border Branch.</i>		
<i>Head to tail, 9 miles, metre gauge—</i>		
Permanent-way laid, 9 miles at Rs. 15,000 per mile ...	1,35,000	
<i>Main Branch.</i>		
<i>The above permanent-way will suffice for laying as sidings the whole way down the Branch so only the cost of lifting and relaying will be required.</i>		
<i>It is possible that sidings will not be required as only two trains a day run each way on the line now, so that materials can be unloaded direct from the main line.</i>		
Lifting and relaying sidings, 53 miles at Rs. 2,500 per mile ...	1,32,500	
<i>Special Tools and Plant (Heavy)—</i>		
10 per cent. of Total 1 (2), Main Canal and Branches ...	Rs. 47,03,232	4,70,823
GRAND TOTAL I. (5).—SPECIAL TOOLS AND PLANT ...		63,68,003

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

II.—ESTABLISHMENT.

The provision for Establishment is made at the rate of 12 per cent. of total I.—Works.

Serial No. of Channels.	Names of Channels.	Amount of I.—Works.	Rate per cent.	Amount of II.—Establishment.
		Rs.		Rs.
1	Main Line Upper	39,20,579	12	4,70,469
2	Grey Canal Feeder	9,90,172	"	1,18,821
3	Main Line Lower	84,82,400	"	10,17,888
4	Abohar Branch Irrigation	2,80,000	"	33,600
5	Abohar-Bhatinda Feeder	72,69,160	"	8,72,299
6	Phul Feeder	17,67,421	"	2,12,090
7	Rori (A-9) Feeder	55,64,473	"	6,67,737
8	Rori Chautala (A-9) Distributaries	20,43,000	"	2,45,160
9	Bhatinda-Bikaner Feeder... ..	70,17,458	"	8,42,095
10	Bikaner Branches	54,46,555	"	6,53,587
11	Bikaner Distributaries	27,63,750	"	3,31,650
12	Abohar Branch Alterations	13,31,633	"	1,59,796
13	Bhatinda Branch Alterations	1,33,204	"	15,995
GRAND TOTAL OF II.—ESTABLISHMENT ...				56,41,187

SUTLEJ DAM PROJECT

LOWER SIRHIND CANAL

III.—TOOLS AND PLANT (ORDINARY).

The provision for Tools and Plant is made at the rate of $1\frac{1}{2}$ per cent. of total I.—Works.

Serial No. of Channels.	Names of Channels.	Total amount of I.—Works.	Rate per cent.	Amount of III.—Tools and Plant.
		Rs.		Rs.
1	Main Line Upper	39,20,579	$1\frac{1}{2}$	58,809
2	Grey Canal Feeder	9,90,172	"	14,853
3	Main Line Lower	84,82,400	"	1,27,236
4	Abohar Branch Irrigation... ..	2,80,000	"	4,200
5	Abohar-Bhatinda Feeder	72,69,160	"	1,09,037
6	Phul Feeder	17,67,421	"	26,511
7	Rori (A-9) Feeder	55,64,473	"	83,467
8	Rori Chautala (A-9) Distributaries	20,43,000	"	30,645
9	Bhatinda-Bikaner Feeder	70,17,458	"	1,05,262
10	Bikaner Branches	54,46,555	"	81,698
11	Bikaner Distributaries	27,63,750	"	41,456
12	Abohar Branch Alterations	13,31,683	"	19,975
13	Bhatinda Branch Alterations	1,33,294	"	1,999
GRAND TOTAL OF III.—TOOLS AND PLANT ...				7,05,148

SUTLEJ DAM PROJECT.**LOWER SIRHIND CANAL.****IV.—SUSPENSE ACCOUNT.**

The provision made of Rs. 8,00,000 is considered to be a fair allowance and the distribution is made as below :—

Serial No. of Channel.	Name of Head.	Amount.
1	Main Line Upper	Rs. 10,000
2	Grey Canal Feeder	20,000
3	Main Line Lower	20,000
4	Abohar Branch Irrigation	10,000
5	Abohar-Bhatinda Feeder	20,000
6	Phul Feeder	5,000
7	Rori (A-9) Feeder	20,000
8	Rori-Chautala (A-9) Distributaries	80,000
9	Bhatinda-Bikaner Feeder	15,000
10	Bikaner Branches	20,000
11	Bikaner Distributaries	80,000
12	Abohar Branch Alterations ... ..	...
13	Bhatinda Branch Alterations ... ..	...
GRAND TOTAL OF IV.—SUSPENSE ...		3,00,000

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

V.—RECEIPTS ON CAPITAL ACCOUNT.

The deduction for receipts on Capital Account is made at the rate of 50 per cent. of I. (5) Special Tools and Plant.

Detail is as below:—

Serial No. of Channel.	Names of Channels.	Amount of I. (5) Special Tools and Plant.	Rate per cent.	Amount of Re- ceipts on Capital Account.
		Rs.		Rs.
1	Main Line Upper	3,56,416	50	1,78,208
2	Grey Canal Feeder ... ..	...	...	...
3	Main Line Lower	9,96,582	50	4,98,291
4	Abohar Branch Irrigation ... ..	...	...	...
5	Abohar-Bhatinda Feeder	13,42,651	50	6,71,326
6	Phul Feeder	3,58,856	50	1,79,428
7	Rori (A-9) Feeder	14,54,952	50	7,27,476
8	Rori-Chautala (A.-9) Distributaries ... ..	...	..	...
9	Bhatinda-Bikaner Feeder	11,20,223	50	5,60,111
10	Bikaner Branches	7,38,323	50	3,69,161
11	Bikaner Distributaries -- ... ..	...	...	...
12	Abohar Branch Alteration ... ..	...	...	...
13	Bhatinda Branch Alteration ... ..	...	...	...
GRAND TOTAL OF V.—RECEIPTS ON CAPITAL ACCOUNT ...				31,84,001

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

VI. (23).—CAPITALIZATION OF ABATEMENT OF LAND REVENUE.

	Annual Revenue. Rs.	Capital Value. Rs.
MAIN LINE UPPER.		
<i>Ludhiana District—</i>		
Mile 2 to mile 8—4,000 feet—		
Chahi land 25 acres at Rs. 2-8 per acre	63	
Barani " 530 " " " 1-12 " "	928	
Total	991	
Capitalized at 25 years' purchase = 25×991 ... ..	...	24,775
NOTE.—The land above mile 2 is included in Head-works.		
GREY CANAL FEEDER.		
<i>Ludhiana District—</i>		
Barani land 241 acres at Rs. 1-12 per acre	422	
<i>Ferozepore District—</i>		
Chahi land 234 acres at Rs. 4 per acre	936	
Barani " 830 " " " 2 " "	1,660	
Total	3,018	
Capitalized at 25 years' purchase = $25 \times 3,018$ ... ..	...	75,450
MAIN LINE LOWER.		
<i>Ludhiana District—</i>		
Chahi land 30 acres at Rs. 2-8 per acre	75	
Barani " 821 " " " 1-12 " "	1,437	
<i>Ferozepore District—</i>		
Nahri land 189 acres at Rs. 1-12 per acre	331	
Barani " 607 " " " 1-6 " "	835	
Total	2,678	
Capitalized at 25 years' purchase = $25 \times 2,678$ ... ..	...	66,950
ABOHAR-BHATINDA FEEDER.		
<i>Ferozepore District—</i>		
Chahi land 33 acres at Rs. 2 per acre	66	
Nahri " 166 " " " 1-12 " "	291	
Barani " 522 " " " 1-6 " "	718	
<i>Patiala State—</i>		
Nahri land 102 acres at Rs. 1-8-0 per acre	153	
Barani " 252 " " " 1-1-3 " "	272	
<i>Ludhiana District—</i>		
Nahri land 158 acres at Rs. 1-4-0 per acre	198	
Barani " 112 " " " 0-12-8 " "	89	
Total	1,787	
Capitalized at 25 years' purchase = $25 \times 1,787$ ... ..	...	44,675
Carried over ... ..	...	2,11,850

**VI (23).—CAPITALIZATION OF ABATEMENT OF LAND
REVENUE—CONCLUDED.**

						Annual Revenue. Rs.	Capital Value. Rs.
PHUL FEEDER.						...	2,11,850
<i>Ludhiana District—</i>							
Nahri land,	14 acres, at Rs.	1-4-0	per acre	...	...	18	
Barani "	56 " " "	0-12-8	" "	...	...	44	
<i>Nabha State—</i>							
Nahri land,	53 acres, at Rs.	1-4-0	" "	...	...	66	
Barani "	212 " " "	0-13-0	" "	...	...	172	
Total					...	300	
Capitalized at 25 years' purchase = 25×300 ...						...	7,500
Note.—Rate of Nabha State is assumed mean of Ludhiana (Jungle) and Ferozepore (Nathana).							
RORI (A-9) FEEDER.							
<i>States—From mile 0 to mile 34—2,000 feet—</i>							
Barani land,	791 acres, at Rs.	0-10-0	per acre	...	...	494	
Nahri "	329 " " "	1-0-0	" "	...	...	329	
<i>Hissar District—</i>							
Barani land,	156 acres, at Rs.	0-3-6	" "	...	...	34	
Total					...	857	
Capitalized at 25 years' purchase = 25×857 ...						...	21,425
Note.—Rates for States are taken mean of—							
		<i>Barani.</i>	<i>Nahri.</i>				
		Rs. a. p.	Rs. a. p.				
Ludhiana (Jungle)	...	0 12 8	1 4 0				
Ferozepore (Nathana)	...	0 13 6	1 4 6				
Hissar (Sirsa and Fatehabad)	...	0 3 6	0 8 6				
Total	...	1 13 8	3 1 0				
Mean	...	0 10 0	1 0 0				
BHATINDA-BIKANER FEEDER.							
<i>Patiala State—From mile 0 to mile 46—1,000 feet—</i>							
Barani land,	927 acres, at Rs.	0-9-6	per acre	...	...	550	
Nahri "	232 " " "	0-14-3	" "	...	...	207	
<i>Ferozepore District, Nathana Tahsil—</i>							
Barani land,	509 acres, at Rs.	0-13-6	per acre	...	...	430	
Nahri "	57 " " "	0-8-0	" "	...	...	73	
<i>Ferozepore District, Fazilka Tahsil—</i>							
Barani land,	136 acres, at Rs.	0-5-6	per acre	...	...	46	
Nahri "	15 " " "	0-8-0	" "	...	...	8	
Total					...	1,314	
Capitalized at 25 years' purchase = $25 \times 1,314$ ...						...	32,850
Rate of Patiala State is assumed means of both Tahsils.							
BIKANER BRANCHES.							
<i>Ferozepore District—</i>							
Barani land,	116 acres, at Rs.	0-5-6	per acre	...	...	40	
Nahri "	106 " " "	0-8-0	" "	...	...	53	
<i>Hissar District—</i>							
Barani land,	171 acres, at Rs.	0-3-6	" "	...	...	37	
<i>Bikaner State—</i>							
Barani land,	1,418 acres, at Rs.	0-8-0	" "	...	...	709	
Total					...	839	
Capitalized at 25 years' purchase = 25×839 ...						...	20,975
GRAND TOTAL VI (23).—CAPITALIZATION OF ABATEMENT OF LAND REVENUE						...	2,94,600

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

VI. (25).—LEAVE AND PENSION ALLOWANCE.

The provision for Leave and Pension Allowance is made at the rate of 14 per cent. of II.—Establishment.

Serial No. of Channels.	Names of Channels.	Amount of II.—Establish- ment.	Rate per cent.	Amount of Leave and Pension Allowance.
		Rs.		Rs.
1	Main Line Upper ...	4,70,469	14	65,866
2	Grey Canals ...	1,18,821	"	16,635
3	Main Line Lower ...	10,17,888	"	1,42,504
4	Abohar Branch Irrigation ..	33,600	"	4,704
5	Abohar-Bhatinda Feeder ...	8,72,299	"	1,22,122
6	Phul Feeder ..	2,12,090	"	29,693
7	Rori (A-9) Feeder ...	6,67,737	"	93,483
8	Rori Chautala (A-9) Distributaries ...	2,45,160	"	34,322
9	Bhatinda-Bikaner Feeder ...	8,42,095	"	1,17,893
10	Bikaner Branches ...	6,53,587	"	91,502
11	Bikaner Distributaries ...	3,31,650	"	46,431
12	Abohar Branch Alterations ...	1,59,796	"	22,372
13	Bhatinda Branch Alterations ...	15,995	"	2,239
GRAND TOTAL OF VI. (25).—LEAVE AND PENSION ALLOWANCE ...				7,89,766

SUTLEJ DAM PROJECT.

SCHEDULE OF RATES.

ITEM.				RATE.
				Rs.
Earthwork Minimum Rate	...	..	...	6 % c. ft.
Concrete	...	...	...	30 % c. ft.
Brick Masonry	...	...	...	35 do.
Well Brick Masonry	...	...	...	32 do.
Arch Masonry	...	...	...	37 do.
Metalling	...	...	..	15 do.
Well Curb	...	...	...	2 and 2-8-0 per l. ft.
Gates and Gearing	...	...	...	40 per s. ft.
Centring	...	...	...	120 and 150 each.
Well Sinking	...	...	..	8 per l. ft.
Bumping Posts	...	...	...	5 each.
Drain Pipes	...	...	...	2 each.
Iron Trough	..	...	...	300 per ton.
Rolled Steel Beams	..	...	...	12 per cwt.
Lime Plaster	...	...	...	5 % s. ft.
Stone Masonry	..	...	...	42 % c. ft.
Dressing Stone Work	...	...	...	0-6-0 per s. ft.
Iron Work	...	...	...	12 per md.
Clearing Grooves between Wells and Staunching	..	...	...	5 per l. ft.
Stone Pitching	...	...	...	18 per % c. ft.
Stone Ballast	...	...	...	10 and 12 do.

Details of other rates such as Preliminary Charges, Land, Earthwork, etc., are given in the Report on Works concerned.

SUTLEJ DAM PROJECT.

—
LOWER SIRHIND CANAL.

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APPENDICES.

SUTLEJ DAM PROJECT**LOWER SIRHIND CANAL.****APPENDIX A.****LIST OF MASONRY WORKS.**

Serial No.	Description.	Page No.
1	Main Line	108—109
2	Grey Canals Feeder	110—111
3	Abohar-Bhatinda Feeder	112
4	Phul Feeder	113
5	Rori (A-9) Feeder	114—115
6	Bhatinda-Bikaner Feeder	116—117
7	Bikaner Main Branch	118—119
8	Bikaner Border Branch	120

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL

TABLE OF WORKS.

MAIN LINE.

Distance from Head in miles of 5,000 feet.	Name of work.	CANAL							DETAILS OF BRIDGES AND REGULATORS.				REMARKS.	
		Land Width, feet.	Discharge, cusecs.	Bed slope 1 in	Bed Width, feet.	F.S. Depth, feet.	V & V/ro.	N.	R. L. of Bed.	Width of Roadway, feet.	Spans.			Depth of digging, feet.
											No.	Width, feet.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Miles. Ft.	MAIN LINE UPPER.													
0 0	ALIVIAL Head Regulator ...		9,259	8,000	184	10	4.77 1.3	.015	749.50	16	16	20	4.0	
2 1,000	Budha Nala Syphon ...	Mean 558.	...	"	"	"	"	"	...	...	...	...	...	Syphon; 3 No. 8 ft. steel tubes.
2 2,000	V. R. Bridge		...	"	"	"	"	"	748.25	10	8	24	4.0	
3 2,000	V. R. Bridge		...	"	"	"	"	"	747.38	10	8	24	2.0	
4 4,000	D. R. Bridge		...	"	"	"	"	"	746.50	14	8	21	14.0	Old Ludhiana-Ferozepur Road.
6 4,000	V. R. Bridge		...	"	"	"	"	"	745.25	10	8	24	14.0	
8 4,000	GREY CANAL FEEDER Head Regulator ...		...				See Table of Works of Grey Canal Feeder.						Draws off 1,000 cusecs.	
	MAIN LINE LOWER.													
8 4,000	SIDHWAN Regulator and D. R. Bridge	Mean 760.	8,213	8,000	163	10	4.77 1.3	.015	744.00	16	9	20	9.0	Pacca Road, Jagraon to Sidhwan.
10 1,000	V. R. Bridge		...	"	"	"	"	"	743.13	10	7	25	11.0	

10	2,000	Drainage Inlet	...	...	3,000	163	10	$\frac{4.77}{1.3}$	015	...	...	...	...	One span of 8.0 ft.
12	500	V. R. Bridge	...	...	"	"	"	"	"	741.94	10	7	25	12.0
13	4,000	V. R. Bridge	...	...	"	"	"	"	"	740.83	10	7	25	15.0
15	1,500	V. R. Bridge	...	...	"	"	"	"	"	739.04	10	7	25	14.0
15	3,000	Drainage Inlet	...	...	"	"	"	"	"	...	...	...	...	One span of 8.0 ft.
17	500	D. R. Bridge	...	...	"	"	"	"	"	738.85	14	7	25	15.5
19	1,205	G. T. Road Bridge	...	...	"	"	"	"	"	737.47	18	7	25	9.0
19	3,105	RAILWAY BRIDGE, S. P. Railway	...	...	"	"	"	"	"	737.23	...	Single Line.	...	Metalled Road, Ludhiana-Ferozepur.
20	500	Drainage Inlet	...	...	"	"	"	"	"	...	...	...	...	Ludhiana-Ferozepur Railway Line, near Agital Station.
21	1,350	V. R. Bridge and Aqueduct	...	...	"	"	"	"	"	736.20	10	7	25	2 spans of 8 ft.
22	3,000	V. R. Bridge	...	...	"	"	"	"	"	735.37	10	7	25	Jagraon Distributary Crossing. Discharge 111 cusecs. Road carried over on top of the Aqueduct of 10 ft. bed width.
24	2,655	V. R. Bridge and Aqueduct	...	...	"	"	"	"	"	734.17	10	7	25	16.0
25	3,000	V. R. Bridge	...	...	"	"	"	"	"	733.60	10	7	25	12.0
26	1,000	Drainage Inlet	...	...	"	"	"	"	"	...	...	...	...	Daudhar Minor Crossing. Discharge 14.5 cusecs. Carried over in steel tube on Piers of Bridge.
27	2,800	Tail Main Line	...	8,204	"	"	"	"	"	732.27	...	...	...	3 spans of 8.0 ft.
27	2,800	ABOHAR BRANCH Head Regulator.	...	...	"	80	9	...	...	732.27	14	4	20	Draws off 3,074 cusecs.
27	2,800	ABOHAR BHATINDA FEEDER Head Regulator.	...	...	...	...	...	...	...	...	...	...	...	Draws off 5,180 cusecs.

See separate Table of Works of Abohar-Bhatinda Feeder.

SUTLEJ DAM PROJECT.
LOWER SIRHIND CANAL.
TABLE OF WORKS.
GREY CANALS FEEDER.

Distance from Head in miles of 5,000 feet.	Miles, Ft.	Name of work.	Land width, feet.	Bed slope 1 in	Value of N.	R. L. of bed.	Bed width, feet.	DETAIL ACCORDING TO 1,000 CUSCS HEAD DISCHARGE.			DETAILS OF 50 PER CENT. EXCESS SUPPLY RUN.				DETAILS OF BRIDGES AND REGULATORS.			REMARKS.
								Dis-charge, cusecs.	F. S. depth, feet.	V & V/ro.	Dis-charge, cusecs.	F. S. depth, feet.	V & V/ro.	Width of road way, feet.	Span. No.	Width.	Depth of digging.	
1		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
0	0	SIDHWAN Head Regulator	...	5,000	0.225	741.72	56	1,074	8.2	265 1.03	1,611	8	3.25 1.02	14	2	20	10.3	
1	2,000	V. R. Bridge	...	"	"	740.32	"	"	"	"	"	"	"	10	3	20	11.5	
2	1,000	3 23 feet Fall and Bridge	...	"	"	738.52 735.30	"	"	"	"	"	"	"	10	2	20	9.0 12.0	
3	3,200	Existing V. R. Bridge	...	"	"	734.8	"	"	"	"	"	"	"	10	...	...	11.4	Alterations to be made.
4	1,000	Do.	...	"	"	734.3	"	"	"	"	"	"	"	10	...	...	12.7	Alterations to be made.
6	3,000	Do.	...	"	"	731.8	"	"	"	"	"	"	"	...	...	...	...	To be dismantled.
6	4,000	7 feet Fall and Bridge	...	"	"	731.7 724.7	56 62	1,074 899	8.2 5.3	20 103	1,611 1,349	8 7	3.1 1.04	10	3	20	5.5 12.5	
9	1,000	KINGWAH canal off-takes V. R. Bridge	...	"	"	722.3	"	"	"	"	"	"	"	10	3	22	7.3	
11	1,500	V. R. Bridge	...	"	"	720.2	"	"	"	"	"	"	"	10	3	22	7.1	

SUTLEJ DAM PROJECT.
LOWER SIRHIND CANAL.
TABLE OF WORKS.
ABOHAR-BHATINDA FEEDER.

Distance from Head in miles of 5,000 feet.	Name of work.	CANAL.							DETAILS OF BRIDGES AND REGULATORS.				REMARKS.	
		Land width, feet.	Discharge, cusecs.	Bed slope 1 in	Bed width, feet.	F. S depth, feet.	V & V/100.	N.	R. L. of bed.	Width of roadway, feet.	Span.			Depth of digging, feet.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Miles. Feet.														
0 0	DAUDHAR Head Regulator and Aqueduct		5,130	6,806	112	90	4.8 1.4	0.15	731.51	14	5	40	11.5	Fall in bed .78, Fall in W. S. 1.76. Wadhwa Distributary Crossing (discharge 60 cusecs) carried over in steel Aqueduct on Piers of Head Regulator.
2 500	V. R. Bridge		"	"	"	"	"	"	729.94	10	5	24	50	5 spans of 80 feet.
2 2,000	Drainage Inlet		"	"	"	"	"	"	"	"	"	"	"	"
3 4,000	V. R. Bridge		"	"	"	"	"	"	728.86	10	5	24	90	"
6 500	D. R. Bridge		"	"	"	"	"	"	720.84	14	5	24	90	"
6 3,500	Drainage Inlet		"	"	"	"	"	"	"	"	"	"	"	"
8 0	V. R. Bridge		"	"	"	"	"	"	725.51	10	5	24	90	"
8 4,100	V. R. Bridge		"	"	"	"	"	"	724.18	10	5	24	90	"
11 4,500	V. R. Bridge		"	"	"	"	"	"	722.50	10	5	24	100	"
13 1,500	V. R. Bridge		"	"	"	"	"	"	721.54	10	5	24	70	"
14 3,000	Drainage Inlet		"	"	"	"	"	"	"	"	"	"	"	"
15 3,500	V. R. Bridge		"	"	"	"	"	"	719.74	10	5	24	170	1 span of 80 feet.
17 500	V. R. Bridge and Aqueduct		"	"	"	"	"	"	718.03	10	5	24	80	Bhadaur Distributary Crossing (discharge 139.1 cusecs) carried over in steel Aqueduct on Piers of Village Road Bridge.
19 2,000	V. R. Bridge		"	"	"	"	"	"	716.98	10	5	24	70	"
20 4,800	V. R. Bridge and Aqueduct		"	"	"	"	"	"	715.79	10	5	24	80	Ghanda-Banna Minor Crossing (discharge 597 cusecs) carried over Piers of Village Road Bridge.
22 2,333	V. R. Bridge and Aqueduct		"	"	"	"	"	"	714.05	10	5	24	90	Dipali Distributary Crossing (discharge 61 cusecs) carried over in steel Aqueduct on Piers of V. R. Bridge.
23 2,500	V. R. Bridge		5,996	6,886	112	90	4.8 1.4	0.15	713.89	10	5	24	100	"
25 65	Tail Abohar Bhatinda Feeder		"	"	"	"	"	"	712.75	"	"	"	120	"
25 65	PHUL FEEDER, Head Regulator, BHATINDA BRANCH, Head Regulator		See separate Table of works of Phul Feeder.	"	54	70	"	"	712.75	"	2	20	120	Dipali draws off 3,898 cusecs. Draws off 1,200 cusecs

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

TABLE OF WORKS.

PHUL FEEDER.

Distance from Head in miles of 5,000 feet.	Name of work.	CANAL.								DETAILS OF BRIDGES AND REGULATORS.				Depth of digging, feet	REMARKS.
		Land Width, feet.	Dis-charge, cu.-ecs.	Bed slope, 1 in.	Bed width, feet.	'F. S. Depth, feet.	V & V/ro.	N.	R. L. of bed.	Width of Roadway, feet.	Span.		Width, feet.		
1	2	3	1	5	6	7	8	9	10	11	12	13	14	15	
Miles Ft. 0 0	DHIPALI Head Regulator and Aqeduct.		3,896	6.666	85.0	9.0	1.01 1.35	.015	712.00		4	20	13	(Fall in bed " 75 ft. Fall in W. S. " 75 ft. Major Minor crossing carried over in steel Aqueduct on Piers of Head Regulator.	
2 500	V. R. Bridge ...		...	"	"	"	"	"	710.43		4	24		9	
3 4,500	V. R. Bridge ...		...	"	"	"	"	"	709.08		4	24		3.5	
5 4,100	V. R. Bridge and Aqeduct ...		.	"	"	"	"	"	707.64		4	24		8.5	Phul Distributary Crossing (discharge 85 cusecs) carried over in steel Aquo-duct on Piers of V. R. Bridge.
6 780	RAILWAY BRIDGE S. P. Railway.			"	"	"	"	"	707.38	Single line.	...	...		8	Bhatinda-Dhuri Line, near Rampura Phul Station.
6 1,000	Tail, Phul Feeder ...		3,859	6.666	85.0	9.0	4.04 1.35	.015	707.35	...	...	...		7	
6 1,000	BHATINDA BIKANER FEEDER, Head Regulator			"	"	"	"	"	707.38		...	...			Draws off 2,307 cusecs.
6 1,000	Phul Distributary Head Regulator.			"	"	"	"	"	707.35		...	...			Draws off 120 cusecs.
1,000	ROHRI (A-9) FEEDER, Head Regulator ...														Draws off 1,462 cusecs.

See separate Table of works of Bhatinda-Bikaner Feeder.

See separate Table of works of Rohri (A-9), Feeder.

See separate Table of works of Bhatinda-Bikaner Feeder.

See separate Table of works of Rohri (A-9) Feeder.

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

TABLE OF WORKS.

RORI (A-9) FEEDER,

Distance from Head in miles of 5,000 feet.	Name of work.	CANAL.								DETAILS OF BRIDGES AND REGULATORS.					REMARKS.
		Land Width, feet.	Discharge, cusecs.	Bed slope, 1 in.	Bed Width, feet.	F. S. Depth, feet.	V and V/vo.	N.	R. L. of bed.	Width of Roadway, feet.	Spans.		Depth of digging, feet.		
											No.	Width, feet.			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Miles Ft.															
0 0	RAMPURA PHUL Head Regulator and Aqueduct.		1,462	6.666	38.0	80	$\frac{4.00}{1.205}$	.015	$\frac{707.25}{705.85}$	14	2	20	8.7	Fall in Bed 15'
1 2,000	V. R. Bridge ...		...	"	"	"	"	"	704.60	10	2	24	9.3	Blunder Minor carried over in steel Aqueduct on Piers of Head Regulator.
3 0	V. R. Bridge ...		...	"	"	"	"	"	703.60	10	2	24	9.2	Fall in W. S. 5.2'
5 0	V. R. Bridge ...		...	"	"	"	"	"	702.10	10	2	24	6.3	
5 3,700	V. R. Bridge ...		...	"	"	"	"	"	701.53	10	2	24	8.1	
5 3,760	Syphon	Average 300.	"	"	"	"	"	"	...	...	...	...	...	Vandi Distributary discharge 25 cusecs syphoned under in 5 feet diameter steel tube.
7 500	V. R. Bridge ...		...	"	"	"	"	"	700.52	10	2	24	9.0	
9 0	V. R. Bridge ...		...	"	"	"	"	"	699.10	10	2	21	6.6	
10 4,000	V. R. Bridge ...		...	"	"	"	"	"	697.75	10	2	21	5.1	
12 500	V. R. Bridge ...		...	"	"	"	"	"	696.77	10	2	24	17.0	
14 800	Syphon		.	"	"	"	"	"	...	...	...	...	...	Chuman Distributary discharge 28 cusecs. Syphoned under in 5 feet diameter steel tube.
14 300	V. R. Bridge ...		...	"	"	"	"	"	695.30	10	2	24	8.9	
15 1,500	V. R. Bridge ...		..	"	"	"	"	"	694.37	10	2	24	8.5	
16 1,130	RAILWAY BRIDGE of S. P. Railway.		..	"	"	"	"	"	693.68	Single line.			9.8	Bhatinda-Jakhal Railway Line near Maur station.	

SUTLEJ DAM PROJECT.
LOWER SIREHIND CANAL.
TABLE OF WORKS.
BHATINDA-BIKANER FEEDER.

Distance from head in miles of 5,000.	Name of Work.	CANAL							DETAILS OF BRIDGES AND REGULATORS.				REMARKS.	
		Land Width, feet.	Discharge, cu.-feet.	Bed slope, 1 in.	Bed Width, feet.	F. S. Depth, feet.	V & V/ro.	N.	R. L. of bed.	Width of Roadway, feet.	Spans.			Depth of digging, feet.
											No.	Width, feet.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Miles F.L. 0 0	RAMPURA PHUL Head Regulator.		2,307	3,000	32	80	178 15	015	705.2	12	2	20	9.5	Fall in bed 2-10'. Fall in W. S. 3-15'.
1 3,500	V. R. Bridge		...	"	"	"	"	"	703.5	10	3	20	5.0	
3 3,500	V. R. Bridge		...	"	"	"	"	"	701.5	10	3	20	5.0	
5 4,000	8.5 ft. Fall and V. R. Bridge		...	"	"	"	"	"	699.4 697.7	10	2	20	9.0	Fall in bed 8.5 ft. Fall in W. S. 8.5 ft.
6 3,000	V. R. Bridge		...	"	"	"	"	"	699.1	10	3	20	9.0	
8 2,000	V. R. Bridge		...	"	"	"	"	"	698.3	10	3	20	12.0	
11 2,000	V. R. Bridge		...	"	"	"	"	"	695.3	10	3	20	5.0	
12 3,000	V. R. Bridge		...	"	"	"	"	"	694.1	10	3	20	8.0	
15 0	2.5' Fall and V. R. Bridge		...	"	"	"	"	"	691.7 679.2	10	2	20	5.0	Fall in bed 2.5 ft. Fall in W. S. 2.5 ft.
17 1,000	V. R. Bridge		...	"	"	"	"	"	679.4	10	3	20	8.0	
19 3,000	V. R. Bridge		...	"	"	"	"	"	671.6	10	3	20	10.0	
19 4,500	RAILWAY BRIDGE of S. P. Railway		...	"	"	"	"	"	671.4		single line		7.0	Bhatinda-Ja'hal Railway Line.
21 0	V. R. Bridge		...	"	"	"	"	"	673.2	10	3	20	8.0	

22 2,000	8' Fall and V. R. Bridge	2,291	"	"	"	"	"	"	671.8 662.8	10	2	20	90	Fall in bed 9'. Fall in W. S. 0'.
22 3,300	RAILWAY BRIDGE of R. M. Ry.	...	"	"	"	"	"	"	602.34	single line			90	Bhatinda-Sirsa Railway line near Bhatinda Station.
23 1,000	V. R. Bridge and Aqueduct	...	"	"	"	"	"	"	661.4	10	3	20	130	Mehra Branch, crossing discharge 25 cusecs, carried over in steel Aqueduct on piers of V. R. B.
25 4,000	V. R. Bridge	...	"	"	"	"	"	"	658.0	10	3	20	70	
27 800	RAILWAY BRIDGE of J. R. Ry.	...	"	"	"	"	"	"	657.68	single line			60	Bhatinda to Hanumangarh near Sungat Station.
27 1,000	V. R. Bridge	...	"	"	"	"	"	"	656.1	10	3	20	85	
29 3,000	V. R. Bridge	...	"	"	"	"	"	"	651.6	10	3	20	40	
31 0	V. R. Bridge	...	"	"	"	"	"	"	654.2	10	3	20	70	
33 1,000	V. R. Bridge	...	"	"	"	"	"	"	651.1	10	3	20	30	
35 1,000	V. R. Bridge	...	"	"	"	"	"	"	649.0	10	3	20	70	
36 3,000	V. R. Bridge	...	"	"	"	"	"	"	646.6	10	3	20	120	
41 4,000	V. R. Bridge	...	"	"	"	"	"	"	643.1	10	3	20	60	
44 1,000	V. R. Bridge	...	"	"	"	"	"	"	641.6	10	3	20	90	
46 1,000	Tail of Bhatinda-Bikaner Feeder.	2,274	54.0	78	1.0	52	0.13	639.0	...	...	...	..	57	Draws of 1,638 cusecs s.
"	BIKANER MAIN BRANCH Head Regulator.													Draws of 518 cusecs; 117 cusecs, absorption saved by lining branches unallocated.
"	BIKANER BORDER BRANCH Head Regulator.													

See separate Table of Works of Bikaner Main Branch.

See separate Table of Works of Bikaner Border Branch.

Average 230.

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

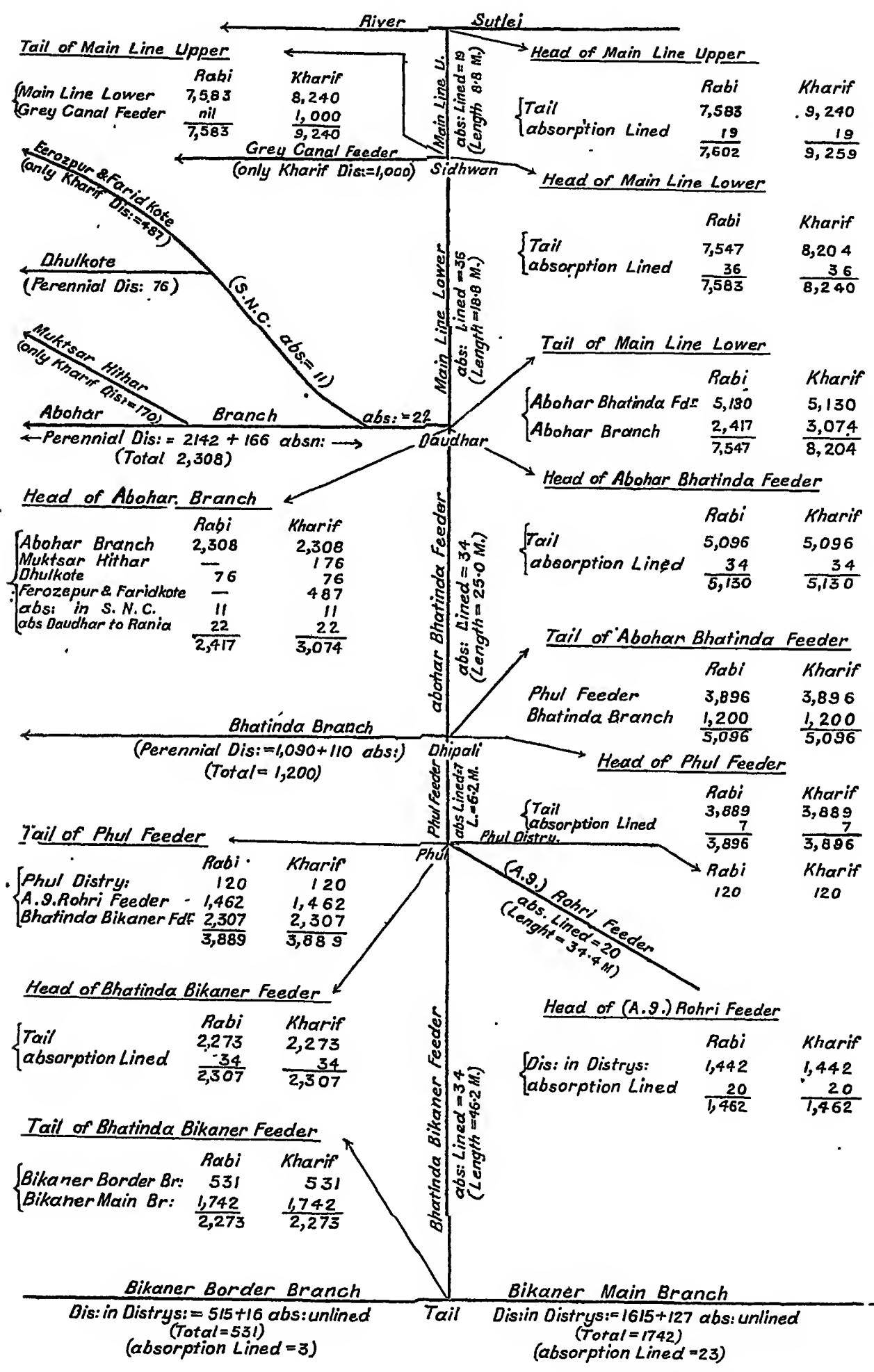
TABLE OF WORKS.

BIKANER MAIN BRANCH.

Distance from Head in miles of 5,000 feet.	Name of work.	CANAL.							DETAILS OF BRIDGES AND REGULATORS.					REMARKS.
		Land width, feet.	Discharge, cusecs.	Bed slope, 1 in.	Bed width, feet.	F. S. depth, feet.	V/ & V/vo.	N.	R. L. of bed	Width of roadway, feet.	Spans.		Depth of digging, feet.	
1	2	3	4	5	6	7	8	9	10	11	No.	Width, feet.	14	15
Miles—Ft.														
0 0	DABWALI Head Regulator	...	1,638	5,000	36	8 0	4'50 1'45	015	037 0	12	2	20	8 0	{ Fall in bed 2 ft. { Fall in W. S. 2 ft.
1 4,540	Syphon	...	...	"	"	"	"	"	...	...	...	...	...	...
3 2,000	V. R. Bridge	...	...	"	"	"	"	"	033'6	10	2	22	4'5	...
6 2,000	V. R. Bridge	...	...	"	"	"	"	"	030'4	10	2	22	4 0	...
9 0	Distributary 1 R.	...	...	"	"	"	"	"	...	...	...	...	...	Draws off 52 cusecs.
" "	3 ft. Fall & V. R. Bridge	...	1,633 1,561	"	36 35	"	4 01 1'45	"	028'0 025'0	10	2	20	3 0 0 0	{ Fall in bed 3 in. { Fall in W. S. 3 ft.
12 0	V. R. Bridge	...	...	"	"	"	"	"	022'0	10	2	22	4 0	...
14 2,500	V. R. Bridge	...	...	"	"	"	"	"	019'8	10	2	22	3 0	...
16 3,500	Syphon	...	...	"	"	"	"	"	...	...	...	...	...	1 barrel of 5 ft. diameter.
17 0	V. R. Bridge	...	...	"	"	"	"	"	017'0	10	2	22	2 0	Draws off 542 cusecs.
18 0	Distributary 2 R.	...	...	"	"	"	"	"	...	...	...	...	...	Draws off 26 cusecs.
" "	Distributary 1 L.	...	...	"	"	"	"	"	...	...	...	...	...	{ Fall in bed nil. { Fall in W. S. 3 ft.
" "	Regulating Bridge	...	1,578 1,008	"	35 25	8 0 7'5	4'14 1'46	"	016'0	10	1	20	4'5	...
21 0	V. R. Bridge	...	...	"	"	"	"	"	013'0	10	2	15	3 0	1 barrel of 5 ft. diameter.
22 0	Syphon	...	...	"	"	"	"	"	...	...	...	...	...	Draws off 10 cusecs
24 0	Distributary 3 R.	...	...	"	"	"	"	"	...	...	...	...	...	...

SUTLEJ DAM PROJECT

DIAGRAM OF CAPACITIES FOR LOWER SIRHIND CANAL SYSTEM.



H. W. NICHOLSON, B. Sc., A. M. I. C. E.,
Executive Engineer,
26th September, 1918.

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

APPENDIX B.

STATEMENTS.

Serial No.	Description.	Page No.
1	Diagram of Capacities for Lower Sirhind Canal System	Opposite.
2	Draw off statement of Bikaner Branches	122—123
3	Do. do. Rori (A-9) Feeder	124
4	Do. do. Bhatinda Branch at Dhipali fed from Abohar-Bhatinda Feeder	125—127
5	Do. do. Abohar Branch at Daudhar fed from Main Lino Lower ...	128—129
6	Statement Showing areas and allocation of water utilized in Main channels of the Lower Sirhind Canal system	130—131
7	Do. do. details of capacity and dimensions of Main Canal and Perennial Feeders with absorption therein for lined and also unlined channels	132—133
8	Do. do. difference of cost of works if channels are constructed lined or unlined	134—135
	Do. do. details of crossings of the existing Distributaries of the Sirhind Canal and the proposed Lower Sirhind Canal channels	136—137
10	Do. do. Stoney Gates required with their estimated cost ...	138
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12	Do. do. distribution of capital cost by tracts irrigated... ..	142—143
13	Do. do. gross areas within irrigation limits of Abohar and Bhatinda Branches affected by Sutlej Dam Project ..	144
14	Do. do. cost of Bridges for various widths of Span and Full Supply Depth	145—146
15	Do. do. working of the existing Sirhind and Western Jumn Canals for the average of 3 years 1911-14 by sections ...	147—149
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17	Existing Capacity statement of Abohar Branch	151
18	" " " " Bhatinda Branch	152

SUTLEJ DAM PROJECT.
LOWER SIRHIND CANAL.

DRAW OFF STATEMENT OF BIKANER BRANCHES, WITH THE ABSORPTION OF MAIN CHANNELS.

Serial No. of channels.	Name of channels.	AREA IN ACRES.				Sinking charge at no cusec per 170 acres of proposed irrigable area.	DETAILS OF MAIN CHANNEL IF LINED.										DETAILS OF MAIN CHANNEL IF UNLINED.									
		Reduced distance of main channel, feet.	Gross area.	Culturable command area = 80 per cent. of gross area.	Proposed irrigable area = 40 per cent. of culturable command area.		Canal.	Dimensions of wetted area.			Absorption at 2 cusecs per one million of wetted area, cusecs.	Total discharge, cusecs.	Canal.			Dimensions of wetted area.			Absorption at 8 cusecs per one million of wetted area, cusecs.	Total discharge, cusecs.	Saving in absorption, cusecs.					
								Bed slope 1 in.	Bed width, feet.	F. S. depth, feet.			Length, feet.	Wetted perimeter, feet.	Wetted area, square feet.	Bed slope 1 in.	Bed width, feet.	F. S. depth, feet.				Length, feet.	Wetted perimeter, feet.	Wetted area, square feet.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24			
BIKANER BORDER BRANCH.																										
1	Distributary 4 L.		53,139	47,825	19,130	113																				
2	Ditto 3 L.	Tail at 44,000	86,362	77,726	31,050	183																				
3	Ditto 2 L.		51,738	46,161	18,620	109																				
4	Ditto 1 L.		51,936	46,712	18,697	110																				
Total of Border Branch.		Head ...	...	...	...	...	5,000	180	60	14,000	350	1,510,000	3	518	...	...	...	...	...	...	...	...	...
BIKANER MAIN BRANCH.																										
1	Tail Distributary	Tail at 265,000	107,500	96,750	38,700	228																				
2	Distributary 5 L.		13,197	11,877	4,751	28																				
3	Distributary 1 L.		...	...	...	...	3,000	120	50	30,000	2611	1,305,300	3	230	...	...	...	...	...	...	...	...	...
4	Distributary 3 L.		12,608	11,347	4,539	27																				
5	Ditto 6 R.	Tail at 163,000	99,712	89,741	35,898	211																				
6	Ditto 5 R.		182,613	164,379	65,753	357		5,000	220	70	2,000	4322	1,210,160	3	515	...	...	...	...	...	...	...	...
			...	...	...	...	5,000	220	70	2,000	4322	1,210,160	3	515	...	...	...	...	...	...	...	...	...

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
7	Distributary 2 L. Ditto 4 R.	14,970 135,000 7,972	13,172 7,055	5,389 2,841	32 17	5,000 ...	23-0 7-5	15,000	41-22	653,300	1	965	5,000	11-0	7-0	15,000	63-8	857,000	8	1,007	7		
8		120,000	...	...	...	...	5,000	25-0	7-5	30,000	18-22	1,246,800	3	1,009	5,000	46-0	7-0	20,000	65-8	1,974,000	16	1,063	13
9	Distributary 3 R.	120,000	18,720	16,553	40	...	5,000	25-0	7-5	30,000	18-22	1,246,800	3	1,009	5,000	46-0	7-0	20,000	65-8	1,974,000	16	1,063	13
10	Distributary 1 L.	30,000	12,173	10,456	26	...	5,000	25-0	7-5	30,000	18-22	1,246,800	3	1,009	5,000	46-0	7-0	20,000	65-8	1,974,000	16	1,063	13
11	Ditto 2 R.	30,000	236,250	230,625	542	...	5,000	25-0	7-5	30,000	18-22	1,246,800	3	1,009	5,000	46-0	7-0	20,000	65-8	1,974,000	16	1,063	13
12	Distributary 1 R.	45,000	24,793	22,114	52	...	5,000	25-0	7-5	30,000	18-22	1,246,800	3	1,009	5,000	46-0	7-0	20,000	65-8	1,974,000	16	1,063	13
	Head ...	...	...	...	...	...	5,000	25-0	7-5	30,000	18-22	1,246,800	3	1,009	5,000	46-0	7-0	20,000	65-8	1,974,000	16	1,063	13
	Total of Bikaner Main Branch.	...	762,032	685,883	271,353	1,615	...	...	...	...	...	...	23	1,698	...	...	...	...	...	...	127	1,742	104
	Total of Bikaner Border Branch.	...	243,175	218,957	57,513	515	...	...	...	...	...	...	3	518	...	...	...	...	...	...	16	531	13
	Grand Total of Bikaner Branches.	...	1,005,207	904,740	351,896	2,130	...	...	...	...	...	...	26	2,156	...	...	...	...	...	...	143	2,273	117

Note.—With the branches lined the saving in absorption will be 117 cusecs making 2,130 + 117 = 2,247 cusecs available in Distributaries.

SUTLEJ DAM PROJECT.
LOWER SIRHIND CANAL.

DRAW OFF STATEMENT OF RORI (A. 9) FEEDER TAKING OFF AT THE TAIL OF PHUL FEEDER OF LOWER SIRHIND CANAL.

DETAIL OF DISTRIBUTARIES.										DETAIL OF MAIN CHANNEL.									
REDUCED DISTANCE OF REACHES.		AREAS IN ACRES.				Discharge required @ 1 cusec. per 170 acres of Proposed Irrigation, cusecs.		CANAL DIMENSIONS.				DIMENSIONS OF WETTED AREA			Absorption @ 2 cu. per million of square feet, cusecs.	Total Discharge at head of Reach, cusecs.	REMARKS.		
Serial No. of Reaches.	Miles.	Name of Distry.	Serial No. of Distry.	Gross area.	Culturable Commanded area 40 per cent. of Gross area.	Proposed Irrigation 40 per cent. of Culturable Commanded area.	Bed Slope 1 in	Bed Width, feet.	Full Supply Depth, feet.	Length in feet.	Wetted Perimeter in feet.	Wetted Area in millions of square feet							
1	2	5	4	6	7	8	9	10	11	12	13	14	15	16	17	18			
1	31	(Tail) 2,000	1	Rania Distry.	148,000 23,000 B. = 11,000	163,800	65,520								At tail 813	B. = Bikaner State.			
				Total	182,000														
			2	Bara Guda Distry.	150,000 B. = 52,000	181,800	72,720	428											
				Total	202,000														
							0.666	20'0	7'6	28,000	45'8	1'2			2	815	
2	28	4,000	3	Chautala Distry.— (a) Kalanwali Mr....	123,000 B = 6,000										815				
				Total	129,000														
				(b) Chantala Distry.	125,000 6,000 4,000 33,000														
				Total	163,000														
				Grand Total of Chautala Distry.	297,000	207,300	106,920	629											
2	0	(Head)		...	...												
				Grand Total of Rori (A. 9) Feeder	681,000	612,900	245,160	1,442											

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

**DRAW OFF STATEMENT OF BHATINDA BRANCH AT DHIPALI WHERE
FED BY ABOHAR-BHATINDA FEEDER OF LOWER SIRHIND CANAL.**

LOWER SIRHIND

(FROM R. D. 292,650 TO

Note.—1. The Mean Irrigation of the Distributaries given above for 3 years (1911—11) was
 2. Column No 29 = $\left(\frac{\text{Column No. 22} \times \text{Column No. 27.}}{170 \times 100.} \right)$
 3. The irrigation proposed under Sulej Dam Project will be 40 per cent. of 484,100

3. The irrigation proposed under Sutlej Dam Project will be 40 per cent. of 464,100

PROJECT.**CANAL.**

WHERE FED BY ABOHAR BHATINDA FEEDER OF LOWER SIRHIND CANAL.

R. D. 500,000 TAIL.)

Serial No. of Distributaries.	Name of Distributaries.	AREAS IN ACRES ACCORDING TO BLUE BOOK STATISTICS 1912-13.			PERCENTAGES OF AREA.				DRAW OFF, CUSECS.		CAPACITY REQUIRED, CUSECS.			
		Gross area.	Culturable command- ed area.	Proposed irrigation.	Per cent. sanctioned.	Per cent. as per working condition.	Per cent. of 3 years (1911-14).	Per cent. proposed.	Sanctioned discharge.	Proposed discharge.	Existing.		Proposed.	
											Rabi.	Kharif.	Rabi.	Kharif.
10	20	21	22	23	24	25	26	27	28	29	30	31	32	33
1	LAL BHAI ...	91,818	82,690	32,350	43	40	52.1	40	165	164				
2	LAMOI ...	127,525	115,160	41,900	40	36	43.7	40	250	271				
3	Jangirana ...	8,300	6,040	1,630	33	30	56.1	40	11	14				
	...	...	...	...	...	...	...	...	...	...	465	465	498	498
4	TEONA ...	91,030	91,310	27,730	33	30	32.8	40	162	215				
	...	...	...	...	...	...	...	...	...	...	643	613	730	730
5	BHATINDA ...	47,440	38,650	11,730	33	30	37.3	40	91	91				
6	BHAIMAN ...	41,615	41,940	12,730	33	30	43.0	40	79	98				
	...	...	...	...	...	...	...	...	...	...	822	822	930	930
	...	...	...	...	...	...	...	...	...	...	528	528	937	937
7	KOT BHAI ...	83,901	60,631	24,500	33	30	39.9	40	163	189				
	...	...	...	...	...	...	...	...	...	...	1,003	1,003	1,140	1,104
	...	...	...	...	...	...	...	...	...	...	1,024	1,024	1,161	1,164
8	Mari ...	10,767	7,550	2,200	33	30	34.8	40	15	18				
	...	...	...	...	...	...	...	...	...	...	1,055	1,055	1,200	1,200
	Total ...	509,116	464,100	155,160	...	...	...	...	956	1,030				

101,330 acres or 25 per cent. in excess of the proposed irrigation 155,160 (column 23).

(Column 22) = 165,640 acres or on the basis of Full Supply Factor of 170 cusecs, column 29 \times 170 = 165,330 acres.

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

DRAW OFF STATEMENT OF ABOHAR BRANCH AT DAODHAR WHERE FED BY MAIN LINE LOWER OF LOWER SIRHIND CANAL.

From R. D. M. 42—3,800 ft. to Tail at R. D. M. 125—4,435 ft.

DETAIL ACCORDING TO EXISTING CONDITIONS.													DETAIL OF DRAW OFF CHANNELS ACCORDING TO BLUE BOOK STATISTICS (1912-13)										DETAIL ACCORDING TO PROPOSED CONDITIONS.			
Fertal No. of Reaches.	Reduced Distance of Reach.		Height of Fall, feet.	Canal Dimensions.			Dimensions of rectified area.			Absorption in millions of square feet.	Absorption in 8 cusecs per 1 million of square feet.	Serial No. of Distributaries.	Name of Distributaries.	Areas in Acres		Existing sanctioned discharge.	Total discharge at head of Reaches.	Draw off charge.	Absorption as per existing condit.	Proposed charge at head of Reaches.		For Rabi, cusecs.	For Kharif, cusecs.			
	Miles.	Feet.		Red slope 1 in	Red Width, feet.	F. S. Depth, feet.	Length, feet.	Wetted perimeter, meter, feet.	Wetted area in square feet.					Gross area	Proposed irrigation.											
1	2	3	4	5	6	7	8	9	10	11	12	13		14	15	16	17	18	19	20	21					
	125	4,435 tail.										1	PANJAWA	72,947	31,810	187	..	187	..	..	..	..	..
	112	4,000	1.5	0.250	22	0.0	63,435	35.4	20.2	19		2	Sarawan	17,210	7,061	34	..	34	..	..	..	..	..
												3	Aspal	17,010	7,056	13	..	43	..	..	..	..	..
												4	MALAKPUR	145,007	51,826	290	..	296	..	..	..	..	..
2	107	2,950	2.18	5.714	30	0.6	26,350	157	1.17	9		5	KARANGARH	19,370	7,052	30	..	50	..	..	..	..	588
3	99	0	3.0	5.714	37	0.6	12,630	147	1.21	13		6	ALAJIWALA	32,397	28,597	67	..	67	..	..	..	..	653
												7	ARNIWALA	171,191	61,917	348	..	348	..	..	..	..	..
4	91	0	3.0	5.711	35	7.4	40,000	220	2.08	17		8	Kaoni	3,220	1,175	7	..	7	..	..	..	..	1,085
												9	Asabutar	4,920	4,920	12	..	12	..	..	..	..	..
5	86	100	1.9	4,000	35	7.6	21,000	520	1.29	10				..	..	..	1.11	..	..	..	..	..	1,114
												10	RUPANA	58,265	21,348	140	..	140	..	..	..	..	..
												11	DODA	63,476	15,858	108	..	108	..	..	..	..	..
7	72	0	0.5	5,892	45	7.6	44,000	620	2.73	22		12	KOT KAPURA	38,803	13,832	76	..	76	..	..	..	..	..
												13	JAYTU	110,673	10,328	221	..	221	..	..	..	..	..

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
8	66	2,000	8.0	5,852	53	7.6	28,000	70.0	1.36	16	14	FARIDKOT	72,306	...	...	1,708	...	16	1,708	1,708
9	57	4,000	9.0	9,250	59	7.6	13,000	75.0	3.24	25	...	NEW AREA OF MUKTSAR HATHAR TO BE IRRIGATED FROM FARIDKOT DISTRIBUTARY.	80,000	K. 12,000	170	...	149 R. 319 K.	...	...	...
10	50	4,000	8.0	6,250	62	7.6	33,000	79.0	2.77	22	...	SIBIAN	28,639	9,960	55	...	55	25	1,882	2,052
11	46	635	...	6,350	84	7.85	13,365	101.5	1.36	11	...	MARI	59,456	20,768	87	...	87	...	...	...
12	42	3,000	10.0	6,600	80	7.85	27,835	97.5	2.69	22	...	Datotal	6,345	1,791	8	...	8	...	...	...
											...	RAOTA	68,004	21,202	175	...	175	22	2,054	2,224
											...	HAGA	42,389	16,210	79	...	79	...	...	...
											...	S. N. O. DHULKOTE	57,543	13,946	76	...	...	11	2,319	2,489
											...	NEW AREA OF FEROZPUR AND FARIDKOT TO BE IRRIGATED FROM S. N. O.	230,000	K. 33,600	487	...	76 R. 563 K.	...	...	...
											...	...	...	...	...	2,417	...	22	2,417	3,074
											...	TOTAL	1,084,373	410,856	...	...	...	...	...	...
											...	TOTAL OF NEW AREAS	310,000	K. 45,000	...	...	...	...	...	...

Note.—The total of culturable commanded area of the existing distributaries given above is 962,638 acres, according to Blue Book Statistics, 1912-13.
The mean irrigation of these distributaries for 3 years 1911-14 was 531,077 acres or 29 per cent. in excess of the proposed irrigation (col. 15).

SUTLEJ DAM

LOWER SIRHIND

STATEMENT SHOWING AREAS AND ALLOCATION OF WATER

Serial No. of source of supply.	Source of supply.	Serial No. of Channels.	Name of Channels.	AREAS IN ACRES.			Proposed discharge in cusecs.
				Gross area.	Culturable commanded area.	Proposed irrigation.	
1	2	3	4	5	6	7	8
1	Bhatinda-Bikaner Feeder .	1	Bikaner Branches :— New ...	1,005,267	901,740	361,896	2,130 } *117 }
2	Phul Feeder ...	2	Bhatinda-Bikaner Feeder :—	..	...	...	...
		3	Rohri (A-9) Feeder :— British New ... Bikaner New ... Total ...	612,000 69,000 681,000	550,800 62,100 612,900	220,320 24,840 245,160	1,296 146 1,442
		4	Phul Distributary :— Present ... Additional ... Total ...	58,666 .. 58,666	51,000 .. 51,000	16,660 3,740 20,400	98 22 120
3	Abohar-Bhatinda Feeder ...	5	Phul Feeder :—	...	...	...	...
		6	Bhatinda Branch :— Present .. Additional .. Total ...	509,116 .. 509,116	464,100 .. 464,100	155,100 50,110 155,300	956 194 1,090
4	Main Line Lower ...	7	Abohar-Bhatinda Feeder :—	..	..	...	...
		8	Abohar Branch :— Present ... (New Kharif) ... Total .	1,084,373 310,000 1,394,373	982,538 279,225 1,241,761	410,456 45,000 455,856	2,216 157 2,875
5	Main Line Upper ..	9	Main Line Lower :—	..	..	..	..
		10	Grey Canal Feeder K.	425,000	382,500	70,000	1,000
6	River Sutlej at Headworks...	11	Main Line Upper :—	...	..	...	..
	Total Existing Channels Present ...			1,650,155	1,477,636	562,676	3,272
	Do. Do. Additional ...			...	...	33,880	156
	TOTAL NEW CHANNELS PERENNIAL ...			1,686,267	1,517,610	607,0	3,699
	Do Do KHARIF ..			785,000	691,725	115,000	1,657
	GRAND TOTAL OF LOWER SIRHIND CANAL ...			4,071,422	3,657,001	1,338,612	8,774

PROJECT.
CANAL.

UTILIZED IN MAIN CHANNELS OF LOWER SIRHIND CANAL.

TOTAL DISCHARGE OF EXISTING DISTRIBUTARIES, CUSECS.		EXTRA SUPPLY GIVEN TO EXISTING DISTRIBUTARIES, CUSECS.		TOTAL DISCHARGE OF NEW DISTRIBUTARIES, CUSECS.		TOTAL ABSORPTION IN MAIN CHANNELS, CUSECS.		TOTAL DISCHARGES AT THE HEAD OF MAIN CHANNELS, CUSECS.		REMARKS.
Rabi.	Kharif.	Rabi.	Kharif.	Rabi.	Kharif.	Rabi.	Kharif.	Rabi.	Kharif.	
9	10	11	12	13	14	15	16	17	18	
...	2,217	2,217	20	20	2,273	2,273	* 117 cusecs is the saving in absorption in case of Channels being lined.
...	...	...	...	...	...	31	31	2,307	2,307
...	...	...	...	1,442	1,442	20	20	1,462	1,462
...	
99	98	22	22	120	120	
...	...	...	...	...	...	7	7	3,896	3,896
959	956	131	131	...	...	110	110	1,200	1,200
...	...	...	...	...	...	34	34	5,130	5,130
2,218	2,218	...	...	...	057	199	199	2,411	3,071
...	...	...	...	...	...	36	36	7,583	8,210
...	...	...	...	...	1,000	...	...	...	1,000
...	...	...	...	...	...	10	10	7,632	9,239
3,272	3,272	...	...	...	...	...	...	...	...
...	...	156	156	...	...	...	...	...	...
...	...	...	...	8,059	3,660	...	...	...	...
...	...	...	...	...	1,037	...	...	...	...
3,272	3,272	156	156	3,089	5,340	485	485	7,602	9,259	

SUTLEJ DAM
LOWER SIRHIND

STATEMENT SHOWING DETAILS OF CAPACITY AND DIMENSIONS OF MAIN CANAL.
UNLINED

Serial No. of channels.	Name of channels	Total length of channels.		DETAIL FOR LINED CHANNEL							
				Discharge required at the tail of reaches of main channels, cusecs.	Canal.			Dimensions of wetted area.		Wetted area in millions of sq. ft.	Absorption at 2 cusecs per million sq. ft. of wetted area, cusecs.
		Miles	Feet.		Bed slope 1 in.	Bed width, feet.	F. S. depth, feet.	Length in feet.	Wetted perimeter, feet.		
1	2	3	4	5	6	7	8	9	10	11	12
1	Bikaner Main Branch	53	0	Detail of absorption given in capacity statement of Bikaner Branches, Appendix B. 2.							23
1 (a)	Bikaner Border Branch	8	4,000								3
2	Bhatinda-Bikaner Feeder	46	1,000	2,273	5,000	52	8.0	231,000	746	17.2	34
3	Rohri (A. D) Feeder	34	2,000	813	6,666	26	7.0	28,000	45.8	1.3	2
				615	6,666	38	8.0	144,000	606	8.7	16
				Total							20
4	Phul Distributary	...	...	...	...	...	...	...	...	...	...
5	Phul Feeder	6	1,000	2,889	6,666	65	9.0	31,000	110.4	3.4	7
6	Bhatinda Branch	...	...	...	...	...	...	...	...	...	...
7	Abohar-Bhatinda Feeder	25	0	5,096	6,666	112	9.0	125,000	137.4	17.1	34
8	Abohar Branch	...	...	...	...	...	...	...	...	...	...
9	Main Line Lower	18	4,000	R. 7,547 K. 5,204	8,000	163	10.0	94,000	181.2	18.0	36
10	Grey Canals Feeder	...	...	...	...	...	...	...	...	...	...
11	Main Line Upper	8	4,000	R. 7,583 K. 8,240	8,000	184	10.0	44,000	212.2	9.34	19
Grand Total											176
Total Bikaner Branches											20
Total Main Canal and Perennial Feeders											150

NOTE.—The unlined channels are designed in accordance with the Official Publication on Normal Data of Design for "Kennedy" Channels, 1917, by F. W. Woods, Esq., Chief Engineer.

PROJECT.**CANAL.****AND PERENNIAL FEEDERS WITH ABSORPTION THEREIN FOR LINED AND ALSO CHANNELS.**

DETAIL FOR UNLINED CHANNELS.												
Discharge draw off in distributaries, c s cs.	Discharge required at the head of reaches of main channels, cusecs.	Discharge required at the tail of reaches of main channels, cusecs.	Canal.			Dimensions of wetted area.		Wetted area in millions of sq. ft.	Absorption at 8 cusecs per million sq. ft. of wetted area, cusecs.	Discharge draw off, cusecs.	Discharge required at the head of reaches of main channels, cusecs.	Saving in absorption in case of lined channels, cusecs.
			Bed slope 1 in	Bed width, feet.	F. S. depth, feet.	Length in feet.	Wetted perimeter, feet.					
13	14	15	16	17	18	19	20	21	22	23	24	25
{ 1,615 } + 117 513	2,273	Detail of absorption, etc., given in capacity statement of Bikaner Branches. Appendix B. 2.						{ 127 } 16	143	2,130	2,273	117
2,273	2,307	2,273	6,668	100	7.5	231,000	121.2	28.0	224	2,273	2,497	190
813	815	813	6,666	55	6.0	25,000	72.0	2.0	16	813	829	102
629	1,462	629	6,666	72	7.0	144,000	91.0	13.22	106	629	1,564	
1,442	1,462					Total ..	...	15.22	122	1,442	1,564	
120	120	...	...	...	...	...	...	...	...	120	120	...
...	3,896	4,181	6,666	165	8.0	31,000	187.6	5.8	46	...	4,227	39
Dis. = 1,690 Abn. = 110	1,200	...	...	...	...	...	...	...	...	1,200	1,200	..
...	5,120	5,427	6,666	200	8.25	125,000	223.3	28.0	224	...	5,651	190
R. 5,417	R. 2,417	...	...	...	...	...	...	...	...	R. 2,417	R. 2,417	...
K. 3,074	K. 3,074	...	...	...	...	...	...	...	...	K. 3,074	K. 3,074	...
...	R. 7,583 K. 8,210	R. 8,068 K. 8,725	8,000	305	65	84,000	328.0	31.0	248	...	R. 8,316 K. 8,973	212
R. Nil	R. Nil	...	...	...	...	...	...	...	...	R. Nil	R. Nil	...
K. 1,000	K. 1,000	...	...	...	...	...	...	...	...	K. 1,000	K. 1,000	...
..	R. 7,602 K. 9,259	R. 8,316 K. 9,973	8,000	350	6.5	41,000	271.0	16.5	132	...	R. 8,448 K. 10,105	113
R. 7,426 K. 9,083	R. 7,602 K. 9,259								1,139	R. 7,309 K. 8,966	R. 8,448 K. 10,105	963
2,247	2,273								143	2,130	2,273	117
R. 5,179 K. 6,836	5,329 6,580								996	R. 5,179 K. 6,836	R. 6,175 K. 7,832	846

Note.—The totals of columns 13 and 23 include absorption in Bhatinda Branch of 110 cusecs and Abohar Branch 189 cusecs. See Appendix B. G.

SUTLEJ DAM PROJECT.
LOWER SIRHIND CANAL.
STATEMENT SHOWING DIFFERENCE OF COSTS OF WORKS IF CHANNELS ARE CONSTRUCTED LINED OR UNLINED.

Serial No. of Lined Channels.	Name of Lined Channels.	Total Length of Channels.		Nature of Channels constructed.	DETAIL FOR FINDING OUT COST OF LINING.										Totals of Different Costs.				Grand Total of cost excluding lining.	REMARKS.
					Canal.		Dimensions of Lined Area.		Rate of lining per cent.	Cost of (L. I.) lining.	Cost of (B.) Land.	Cost of Earthwork.	Cost of Masonry Works (D.) Regulators (G.I.) Bridges (G.I.) Canal Crossings.							
Miles.	Feet.	5	6	7	8	9	10	11	12	13	14	15	16	17						
1	2	3	4																	
1	Bikaner Main Branch ...	53	0	Lined	38	8.0	45,000	81.4	2,783,000											
					35	8.0	45,000	60.1	2,718,000											
					25	7.5	30,000	47.6	1,428,000											
					23	7.5	15,000	17.0	705,000											
					22	7.5	28,000	46.0	1,288,000											
					13	5.0	52,000	30.0	1,600,000											
					12	5.0	30,000	29.0	1,450,000											
				Total	...	...	...	...	11,012,000	2	23,82,400					
				Unlined	60	8.0	45,000	55.4	2,843,000											
					58	8.0	45,000	53.1	2,753,000											
					46	7.0	30,000	48.8	2,058,000											
					44	7.0	15,000	66.6	990,000											
					42	7.0	28,000	61.6	1,509,800											
					34	5.0	52,000	41.0	2,132,000											
					20	5.0	50,000	37.0	1,850,000											
				Total	...	...	...	...	10,413,800	20	32,88,760					
1 (a)	Bikaner Border Branch ...	8	4,000	Lined	18	0.0	14,000	37.8	1,803,200											
				Unlined	30	6.0	41,000	49.8	2,101,200	20	4,38,240									

1	Bikaner Branches	...	...	...	Lined	...	...	...	13,576,200	20	27,15,010	62,352	5,34,898	2,62,045	8,79,283
					Unlined	...	...	...	18,635,800	20	37,27,000	1,37,000	8,91,000	4,37,000	11,63,000
					Difference	...	...	...	.	...	10,11,980	54,648	3,56,101	1,74,955	5,85,707
2	Mhatinda-Bikaner Feeder	48 1,000	...	52	80	231,000	77.1	17,873,100	20	33,75,880	6,31,810	8,44,705	3,60,082	18,36,597	
				100	7.5	231,000	124.0	28,614,000	20	57,28,800	12,15,000	18,24,000	6,92,000	35,31,000	
				...	...	...	...	...	...	21,52,820	6,83,180	7,79,205	3,31,918	16,94,403	
3	Rohri (A-9) Feeder	34 2,000	...	35	80	144,000	63.4	9,729,600	...	...	...	...	...	...
				26	7.0	28,000	18.6	1,360,800	...	...	...	...	...	...
				...	...	Total	...	10,490,100	20	20,98,080	3,52,618	1,77,470	4,30,105	12,60,223	
				72	7.0	144,000	21.6	13,622,400	...	...	...	...	...	...
				55	6.0	28,000	71.8	2,094,400	...	...	...	...	...	...
				...	...	Total	...	13,716,800	20	31,13,360	6,68,000	9,05,000	9,15,000	23,88,000	
				...	...	...	...	...	...	10,15,280	3,15,352	4,27,530	3,84,695	11,27,777	
4	Phul Feeder	6 1,000	...	85	9.0	31,000	113.2	3,509,200	20	7,01,810	1,17,519	1,60,678	2,28,399	5,04,596	
				165	8.0	31,000	190.4	5,902,100	20	11,60,180	2,28,000	3,13,060	4,30,000	9,90,000	
				...	...	...	...	...	...	178,610	1,10,481	1,52,322	2,12,601	1,75,401	
5	Abbar-Bhatinda Feeder	25 0	...	112	9.0	125,000	140.2	17,525,000	20	35,05,000	6,00,082	10,47,947	1,88,330	21,38,359	
				200	8.25	125,000	226.1	28,262,500	20	56,52,500	10,72,000	18,72,060	8,72,000	38,16,000	
				...	...	...	...	...	...	21,47,500	4,71,918	8,24,053	3,83,670	16,79,641	
6	Main Line Lower	18 4,000	...	163	10.0	91,000	194.0	18,236,000	20	36,47,260	6,20,166	23,94,604	5,28,109	35,48,079	
				305	8.5	91,000	331.8	31,189,200	20	62,37,840	11,60,000	41,83,000	9,88,000	68,31,000	
				...	...	...	...	...	...	25,90,840	5,39,834	20,88,197	4,59,891	30,87,922	
7	Main Line Upper	8 4,000	...	181	10.0	44,000	215.0	9,460,000	20	16,92,000	1,53,699	7,79,616	3,58,122	11,91,437	
				350	8.5	44,000	376.8	16,576,200	20	33,15,540	2,92,000	14,83,000	10,62,000	28,37,000	
				...	...	...	...	...	...	11,23,840	1,38,301	7,03,384	5,03,878	13,45,583	
Total cost of Main Canal and Feeders constructed as lined channels										...	1,54,20,000	24,75,924	57,05,219	25,91,147	1,07,72,490
"										...	2,52,58,820	46,35,000	1,06,80,000	48,68,000	2,01,83,000
"										...	98,38,820	21,59,076	49,74,781	22,76,853	94,10,710
										...					

Notes.—(1) Increase in cost of constructing lined channels instead of unlined ones would be Rs. (1,54,20,000—94,10,710) = Rs. 60,09,290.
(2) To line the channels afterwards if constructed unlined would cost Rs. 2,52,58,820.

SUTLEJ DAM

LOWER SIRHIND

STATEMENT SHOWING DETAILS OF CROSSINGS OF THE EXISTING DISTRIBUTARIES

Serial No.	Serial number according to New Channels	Name of Channels.	CANAL.						DISTRIBUTARY			
			Reduced Distance.		Bed width, feet.	Bed level.	F. S. level.	F. S. depth, feet.	Reduced Distance.		Bed width, feet.	Bed slope 1 in.
			Mile.	Feet.					Mile.	Feet.		
1	2	3	4	5	6	7	8	9	10	11	12	13
MAIN LINE.												
1	1	JAGRAON Distributary from Abohar Branch.	21	1,860	183.0	736.20	746.20	10.0	9	2,400	15.0	4,444
2	2	DAODIAR Branch of Jagraon Distributary.	24	2,655	163.0	734.17	744.17	10.0	4	500	6.0	3,620
ABOHAR-BHATINDA FEEDER.												
3	1	WADNI Distributary from Abohar Branch.	0	2,495	112.0	731.00	740.00	9.0	0	4,627	8.0	3,636
4	2	MANOKI Distributary from Abohar Branch.	3	2,275	112.0	726.02	737.02	9.0	20	1,082	5.0	5,000
5	3	BILASPORE Minor of Raekot Distributary.	7	4,898	112.1	723.55	734.55	9.0	3	4,919	4.0	2,657
6	4	RAEKOT Distributary from Bhatinda Branch.	0	4,100	112.1	724.15	733.15	9.0	24	3,836	6.0	4,000
7	5	BHADAUR Distributary from Bhatinda Branch.	17	613	112.0	718.68	727.68	9.0	7	2,954	18.0	4,000
8	6	GHANDA BANA Minor of Dhipali Distributary.	20	3,228	112.0	716.62	725.02	9.0	1	2,905	4.0	3,657
9	7	DHIPALI Distributary from Bhatinda Branch.	23	2,333	112.0	714.66	723.66	9.0	12	2,972	11.0	4,444
PHUL FEEDER.												
10	1	MARI Minor from Bhatinda Branch...	...	...	...	...	...	...	...	...	...	...
11	2	PHUL Distributary from Bhatinda Branch.	5	4,100	85.0	707.63	716.63	9.0	0	2,135	20.0	4,000
ROHRI A-D. FEEDER.												
12	1	*BHUNDAR Minor of Phul Distributary	1	495	38.0	701.36	712.36	8.0	2	4,500	6.0	2,657
13	2	*MANDI Distributary from Kotla Branch.	5	3,760	38.0	701.54	703.54	8.0	15	1,560	5.0	5,714
14	3	*GHUMAN Distributary from Kotla Branch.	14	300	38.0	695.29	703.29	8.0	14	74	5.0	5,000
15	4	*MAUR Branch of Ghuman Distributary.	16	4,530	38.0	693.17	701.17	8.0	7	3,800	2.0	5,000
16	5	*KOTLA Branch	17	523	38.0	693.00	701.00	8.0	67	3,526	28.0	4,545
17	6	*SANDOHA Branch of Bhoni Distributary.	19	200	38.0	691.57	699.57	8.0	4	3,322	4.0	5,000
18	7	*JAGA Branch of Bhoni Distributary	24	600	38.0	687.76	695.76	8.0	7	3,493	3.0	5,714
19	8	MUSHA Branch of Bhili Distributary	32	250	26.0	681.81	689.81	7.0	26	2,464	3.0	6,666
BHATINDA-BIKANER FEEDER.												
20	1	MEHTA Branch of Bhatinda Distributary from Bhatinda Branch	23	4,000	52.0	661.40	669.41	6.0	4	1,250	..	...

*Native State Channels.

PROJECT.**CANAL.****OF THE SIRHIND CANAL AND THE PROPOSED LOWER SIRHIND CANAL CHANNELS.**

DISTRIBUTARY.					Existing difference of Levels:— Bed of Distributary and F. S. of crossing as levelled.	Method of Crossing.	Changes in Distributary if any.
Bed level.	F. S. level.	F. S. depth, feet.	Discharge, feet.	Velocity.			
14	15	16	17	18	19	20	21
A 753.38 B 753.38	750.08 759.98	3.6 3.6	111.0	1.84	7.18	Masonry aqueduct carried over on arches under road, bed width 10 ft. and 8 ft. deep.	No change in Distributary is necessary as there is fall in Distributary D. S. Increases from 1.84 ft. to 3.7 ft. velocity causes small loss in head only.
A 747.30	749.18	1.8	14.5	1.18	3.19	8 ft. diameter steel pipe carried over on piers of V. R. Bridge.	No change in Distributary is necessary.
A 742.25 B 742.41	744.15 741.72	1.90 2.28	21.0	1.28	2.44	Steel trough aqueduct 5 ft. x 5 ft. carried over on piers of Head Regulator of Abohar-Bhatinda Feeder.	New head reach to be constructed which becomes the tail of the Bhiwani Wadni Feeder Distributary from the Upper Sirhind Canal system.
A 739.47 B 739.67	741.47 742.56	2.00 2.89	12.0	1.04	1.75	No crossing	Linked on to Wadni Distributary.
A 735.75 B 733.84	737.25 735.07	1.50 1.83	8.0	1.08	-0.71	Do.	Ditto ditto.
A 734.57 B 733.70	736.57 730.24	2.00 2.54	19.0	1.25	0.55	Do.	Ditto ditto.
A 726.14 B 726.88	729.64 729.72	3.50 2.54	139.1	2.00	-0.80	Steel trough aqueduct 5 ft. x 5 ft. carried over on piers of V. R. Bridge.	F. S. and Bed Level of Distributary raised by 3.04 ft. for 10,000 ft. upstream of crossing up to 3.5 ft. fall at R. D. 28,030 of the Distributary.
A 725.50 B 725.49	726.80 727.27	1.30 1.78	5.97	1.00	0.47	Steel trough aqueduct 3 ft. x 3 ft. carried over on piers of V. R. Bridge.	Bed raised 1 ft. 8 ft. rise in Distributary at head of minor and balance by raising bed of minor and flattening bed slope which is 1 in 2,857.
A 723.12 B 722.93	726.12 726.03	3.00 3.10	61.0	1.60	-0.73	Steel trough aqueduct 5 ft. x 5 ft. carried over on piers of V. R. Bridge.	2 ft. and 8 ft. falls at R. D. 7,030 ft. and 26,000 ft. upstream eliminated and supply level raised 2.8 ft. at crossing.
...	...	...	...	...	...	Steel trough aqueduct 5 ft. x 5 ft. carried over on piers of Head Regulator of Phul Feeder.	A new head is given above Balloki fall from the Phul Distributary.
A 714.31 B 714.60	717.91 718.10	3.60 3.50	163.0	2.00	-2.03	Steel trough aqueduct 5 ft. x 5 ft. carried over on piers of V. R. Bridge.	Falls of 1.02 ft. and 3.23 ft. at R. Ds 35,715 and 45,870 eliminated and F. S. raised by 4.85 ft.
A 712.77 B 712.60	714.07 714.60	1.30 2.00	9.0	1.10	0.24	Steel trough aqueduct 5 ft. x 5 ft. carried over on piers of Head Regulator of Rohri (A-9) Feeder.	The bed of Phul Distributary is raised as above to get it across the Phul Feeder which gives ample headway for the minor crossing.
A 708.06 B 703.70	711.90 713.20	3.90 4.50	25.0	...	-0.84	Syphon 1 steel tube 5 ft. diameter	None, head lost less than 1 ft.
A 702.19 B 701.50	705.69 704.50	3.50 3.00	28.0	...	-1.79	Ditto	Ditto ditto.
A 702.18 B 702.30	705.28 706.60	3.10 4.30	8.0	...	1.13	Steel trough aqueduct 3 ft. x 3 ft. carried over on piers of V. R. Bridge.	None, no head lost.
A 697.56 B 696.80	703.56 702.20	6.00 5.40	517.0	...	-4.20	Syphon 3 barrels of 8 ft. diameter	None, head lost less than 0.1 ft.
A 698.51 B 699.50	703.31 702.90	4.80 3.40	50.0	...	-0.07	Syphon 1 steel pipe of 5 ft. diameter	Ditto ditto.
A 695.24 B 696.80	699.34 699.80	4.10 3.30	28.0	...	0.84	Ditto ditto	Ditto ditto.
A 689.64 B 687.70	691.04 691.70	4.40 3.00	20.0	...	-2.11	Ditto ditto	Ditto ditto.
A 674.20	676.00	1.80	25.0	...	4.60	Steel trough aqueduct 5 ft. x 5 ft. carried over on piers of V. R. Bridge.	None.

NOTE.—A. Levels taken from Longitudinal Sections. B. As levelled in Sindh Dan Project Surveys.

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

STATEMENT SHOWING STONEY GATES REQUIRED WITH THEIR ESTIMATED COST.

Serial No. of channels.	Name of channels for heads of which stoney gates required	DIMENSION OF STONEY GATES			Area of stoney gates in square feet.	Rate per one square foot.	Total cost of stoney gates.	REMARKS.
		No. of spans.	Width of each span, feet.	Height, feet.				
1	2	3	4	5	6	7	8	9
(1)	HEAD WORKS—					Rs.	Rs.	
	Weir	28	60	10·0	16,800	40	6,72,000	
	Under-drains	8	80	10·0	2,400	40	96,000	Both in same grooves.
			30	8·0	1,920	40	76,800	
(2)	MAIN CANAL AND BRANCHES—							
	Head Regulators—							
1	Main Line Upper	16	20	4·0	1,280	40	51,200	Both in same grooves.
			20	4·0	1,280	40	51,200	
2	Grey Canals Feeder	2	20	10·0	400	40	16,000	
3	Main Line Lower	9	20	10·0	1,800	40	72,000	
4	Abohar Branch	4	20	10·0	800	40	32,000	
5	Abohar-Bhatinda Feeder	5	20	10·0	1,000	40	40,000	
6	Bhatinda Branch	2	10	9·0	360	40	14,400	
7	Plul Feeder	4	20	9·0	720	40	28,800	
8	Rohri (A-9) Feeder	2	20	9·0	360	40	14,400	
9	Bhatinda-Iikaner Feeder	2	20	9·0	360	40	14,400	
10	Bikaner Border Branch	1	20	5·5	110	40	4,400	
11	Bikaner Main Branch	6	20	8·0	960	40	38,400	
	Total	89	...	...	30,550	40	12,22,000	
ABSTRACT.								
		28	60	...	16,800	40	6,72,000	
		18	80	...	4,320	40	1,72,800	
		43	20	...	8,430	40	3,37,200	
	Total	89	...	...	30,550	40	12,22,000	

SUTLEJ DAM PROJECT.

— — — — —
LOWER SIRHIND CANAL.
— — — — —

**ABSTRACT STATEMENT SHOWING NUMBER AND DETAILS OF SPANS OF
BRIDGES ON MAIN CHANNELS.**

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

ABSTRACT STATEMENT SHOWING NUMBER AND DETAILS OF SPANS OF BRIDGES ON MAIN CHANNELS.

Serial No. of channels.	Name of channels.	Distance.		Canal.		No. of brid- ges.	Detail of bridges.			Width of spans.							Remarks.			
		From Miles. Feet.	To Miles. Feet.	Bed width, feet.	F S. depth, feet.		Width of road- way, feet.	Spans. No.	Width, feet.	10 ft.	15 ft.	18 ft.	20 ft.	22 ft.	24 ft.	25 ft.				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	Main Line Upper	Head.	8	4,000	184	10-0	1	16	16	16	20	...	...	...	...	...	...	...	...	...
2	Grey Canals Feeder	Head.	6	4,000	58	8-0	1	14	8	24	...	...	...	...	...	...	...	...	...	...
							3	10	8	24	...	...	...	...	...	...	...	...	...	...
							1	11	2	20	...	...	...	...	...	...	...	...	...	...
							1	10	3	20	...	...	...	...	...	...	...	...	...	...
							1	10	2	20	...	...	...	...	...	...	...	...	...	...
							1	10	3	20	...	...	...	...	...	...	...	...	...	...
							2	10	3	23	...	...	...	...	...	...	...	...	...	...
							1	10	2	20	...	...	...	...	...	...	...	...	...	...
							5	10	2	22	...	...	...	...	...	...	...	...	...	...
							2	10	2	18	...	...	...	...	...	...	...	...	...	...
3	Main Line Lower	8 4,000 (Head).	27	2,800	163	10-0	1	16	9	20	...	...	...	...	...	...	...	...	...	...
							1	16	7	25	...	...	...	...	...	...	...	...	...	...
							1	14	7	25	...	...	...	...	...	...	...	...	...	...
							8	10	7	25	...	...	...	...	...	...	...	...	...	...
4	Abohar Branch	Head Regulator.				80	9-0	1	14	4	20	...	...	...	...	...	...	...	...	...

SUTLEJ DAM
LOWER SIRHIND
STATEMENT SHOWING DISTRIBUTION OF

Serial No. of Channels.	Names of Channels.	Discharge on which cost shared, cusecs.		Total water utilized, cusecs.		Total cost of Channel. Rs.	Bikaner.		Rori Chautala Tract.	
		Discharge.	Absorption.	Discharge.	Absorption.		Share.	Cost. Rs.	Share.	Cost. Rs.
1	2	3	4	5	6	7	8	9	10	11
1	Bikaner Distributaries ...	2,130	117	...	...	32,63,287	All	32,63,287	...	...
2	Bikaner Branches ...	...	...	2,247	26	59,45,158	All	59,45,158	...	...
3	Bhatinda-Bikaner Feeder ...	...	...	2,273	34	75,70,447	All	75,70,447	...	...
4	Rori Chautala Distys. ...	1,442	...	...	...	24,33,127	..	...	All	24,33,127
5	Rori (A. 9) Feeder ...	...	...	1,442	20	57,23,109	...	...	All	57,23,109
6	Phul Distributary ...	...	...	120	...	Nil.	...	...	...	...
7	Phul Feeder ...	...	...	3,969	7	16,68,787	$\frac{2,307+4}{3,896}$	11,08,500	$\frac{1,462+3}{3,896}$	7,02,600
8	Bhatinda Branch Irrigation ...	1,090	...	...	...	Nil.	...	...	...	...
9	Do. Alterations ...	...	...	1,090	110	1,53,627	...	...	...	...
10	Abohar-Bhatinda Feeder ...	...	...	5,096	34	77,65,967	$\frac{2,311+15}{5,130}$	35,21,000	$\frac{1,465+10}{5,130}$	22,23,000
11	Abohar Branch Irrigation ...	2,375	...	...	...	3,32,504	...	...	...	...
12	Do. Alterations ...	...	...	2,676	189	15,33,776	...	...	...	...
13	Main Line Lower ...	...	...	8,204	36	93,58,637	$\frac{2,326+10}{8,240}$	78,53,000	$\frac{1,475+6}{8,240}$	16,82,000
14	Grey Canals Feeder ...	1,000	...	...	...	12,35,931	...	...	...	...
15	Main Line Upper ...	...	...	8,240	19	43,72,280	$\frac{2,336+5}{8,259}$	11,05,800	$\frac{1,481+3}{8,259}$	7,01,000
Total ...		...	...	...	...	5,15,50,595	...	2,51,67,190	...	1,34,75,036
Headworks ...		...	...	...	...	76,90,702	$\frac{2,341}{8,259}$	19,45,600	$\frac{1,484}{8,259}$	12,32,600
Total including Headworks ...		...	...	...	...	5,92,47,297	...	2,71,12,790	...	1,47,07,636
Headworks if Grey Canals share not counted ...		...	...	...	...	76,90,702	$\frac{2,341}{8,259}$	21,80,900	$\frac{1,484}{8,259}$	13,81,900
Total including Headworks if share of Grey Canals not considered.		...	...	...	...	5,92,47,297	...	2,73,48,090	...	1,48,56,936
Cost for one acre of Gross commanded area if share of Headworks is taken in Grey Canals.		...	...	...	...	$\frac{2,71,12,790}{10,05,267}$	27.0	$\frac{1,47,07,636}{6,81,000}$	21.6	
Cost for one acre of Gross commanded area if share of Headworks is not taken in Grey Canals.		...	...	...	...	$\frac{2,73,48,090}{10,05,267}$	27.2	$\frac{1,48,56,936}{6,81,000}$	21.8	

PROJECT.**CANAL.****CAPITAL COST BY TRACTS IRRIGATED.**

Supplying existing Sirhind Canal Channels.		Grey Canals.		Bhatinda Branch Irrigation.		Abohar Branch Irrigation.		Remarks.
Share.	Cost. Rs.	Share.	Cost. Rs.	Share.	Cost. Rs.	Share.	Cost. Rs.	
12	13	14	15	16	17	18	19	20
...	
...	
...	
...	
...	
98	...	...	...	22	...	...	...
$\frac{68}{2,896}$	47,000	...	...	$\frac{22}{2,896}$	10,467	...	...
...	
All	1,53,527	...	...	..	...	...	...
$\frac{1,104+3}{5,130}$	17,71,300	...	...	$\frac{156+1}{5,130}$	2,37,667	...	...
...	...	..	..	...	...	All	3,32,504	
...	...	...	..	All	...	..	...
$\frac{3,569+16}{8,240}$	40,04,500	..	...	$\frac{167+1}{8,240}$	1,79,500	$\frac{667+3}{8,240}$	7,49,687	
...	.	All	12,85,931	...	...	...	...
$\frac{8,665+8}{8,259}$	17,06,000	$\frac{1,000+2}{9,252}$	4,73,000	$\frac{158}{9,259}$	74,490	$\frac{660+1}{9,259}$	3,12,000	
...	77,75,327	...	17,08,931	...	20,35,920	...	13,94,191	
$\frac{3,613}{8,259}$	30,01,000	$\frac{1,002}{9,259}$	8,31,300	$\frac{158}{9,259}$	1,31,202	$\frac{661}{9,259}$	5,49,000	
...	1,07,76,327	...	25,40,231	.	21,67,122	...	19,42,191	
$\frac{3,414}{8,259}$	23,65,200	...	...	$\frac{158}{8,259}$	1,47,102	$\frac{661}{8,259}$	6,15,600	
...	1,11,40,527	..	17,08,931	...	21,83,022	.	20,08,791	
...	...	$\frac{25,40,231}{4,25,000}$	6.0	...	...	$\frac{19,42,191}{3,10,000}$	6.3	
...	...	$\frac{17,08,931}{4,25,000}$	4.0	...	...	$\frac{20,08,791}{3,10,000}$	6.5	

SUTLEJ DAM PROJECT.**LOWER SIRHIND CANAL.**

STATEMENT SHOWING GROSS AREAS WITHIN IRRIGATION LIMITS OF ABOHAR AND BHATINDA BRANCHES AFFECTED BY THE PROJECT.

Description.	Area in acres taken from 1"=4 mile map of project.	REMARKS.	
1	2	3	
ABOHAR BRANCH.			
Below Gholia Fall	981,840	(Gross area according to statistics 1912-13=1,084,373 acres).	
Dhu'kot, Baga and Raota Distributaries ...	190,464		
Total below Daodhar Fall ...	1,122,804		
BHATINDA BRANCH.			
Below Dhipali Distributary	512,000	(Gross area according to statistics 1912-13 = 509,116 acres).	
NOTES.			
Description.	Abohar Branch.	Bhatinda Branch.	REMARKS.
1	2	3	4
1. Gross area according to Statistics 1912-13	1,084,373	509,116	} See Appendices B. 4 and B. 5.
2. Proposed irrigation do. do.	410,856	155,160	
3. Proposed Irrigation taken in the Project being 40 per cent. of 90 per cent. of gross area in line-1 above.	390,374	183,282	
4. The Mean Irrigation for 3 { Rabi ...	359,375	134,388	
years 1911-14. { Kharif ...	172,302	60,292	
Total ...	531,677	194,680	

SUTLEJ DAM PROJECT.

STATEMENT SHOWING THE WORKING OF THE DISTRIBUTARIES ON THE EXISTING SIRHIND AND WESTERN JUMNA CANALS FOR THE AVERAGE OF 3 YEARS 1911—14 BY SECTIONS ACCORDING TO WHICH THE CHANGES WILL TAKE PLACE UNDER THE SUTLEJ DAM PROJECT.

SUTLEJ DAM

STATEMENT SHOWING THE WORKING OF THE DISTRIBUTARIES ON THE EXISTING
BY SECTIONS ACCORDING TO WHICH THE CHANGES

Serial No. of item.	Items.	Source of information.	LOWER SIRHIND CANAL PROPOSED.		UPPER SIRHIND		
			SIRHIND CANAL EXISTING.				
			Abolhar Branch below Daudhar at mile 43, perennial distributaries.	Bhatinda Branch head to Dhipali at mile 56, perennial distributaries.	Abolhar Branch head to Daudhar at mile 43, perennial distributaries.	Bhatinda Branch head to Dhipali at mile 56, perennial distributaries.	Abolhar and Bhatinda Branches, Kharif distributaries.
1	2	3	4	5.	6	7	8
1	Gross area within irrigation limit ...	S. Statement, 1912-13 ...	1,084,373	565,782	187,995	518,091	152,191
2	Culturable commanded area ...	Ditto ...	902,598	515,100	173,058	445,214	139,569
3	Area proposed to be irrigated ...	Ditto ...	410,558	171,820	60,800	121,740	15,330
4	Per cent. of culturable commanded area proposed to be irrigated in remodelling, 1905.	Remodelling, records ...	40 %	33½ %	40 %	33½ %	10·6 %
5	Per cent. of culturable commanded area on present working figures.	Line 3+line 2 ...	43 %	33 %	34 %	27 %	11 %
6	Total area irrigated in both crops ...	S. Statement, av. 1911-14	531,677	215,010	59,753	133,262	23,683
7	Percentage area irrigated on G. C. A.	Line 6+line 1 ..	49 %	39 %	32 %	25 %	16 %
8	Percentage area irrigated on C. C. A.	Line 6+line 2 ..	55 %	42 %	34 %	30 %	17 %
9	Area irrigated in Kharif ...	S. Statement, av. 1911-14	172,302	67,307	19,218	44,790	10,241
10	Percentage area irrigated in Kharif on G. C. A.	Line 9+line 1 ..	16 %	12 %	10 %	9 %	7 %
11	Percentage area irrigated in Kharif on C. C. A.	Line 9+line 2 ...	19 %	13 %	11 %	10 %	7 %
12	Area irrigated in Rabi ...	S. Statement, av. 1911-14	359,375	147,703	40,540	88,472	13,442
13	Percentage area irrigated in Rabi on G. C. A.	Line 12+line 1 ...	33 %	26 %	22 %	17 %	10 %
14	Percentage area irrigated in Rabi on C. C. A.	Line 12+line 2 ...	37 %	28 %	23 %	20 %	10 %
15	Proportion Kharif : Rabi irrigation	Line 9+line 12 ...	1:2·08	1:2·19	1:2·11	1:1·97	1:1·31
16	Average Number of days canal ran, Kharif...	S. Statement, av. 1911-14	<—————161—————>				
17	" " " " " " Rabi ...	Ditto	<—————177—————>				
18	Time factor, Canal Main Line, Kharif ...	Line 16+183 ...	<—————85—————>				
19	" " " " " " Rabi ...	Line 17+182 ...	<—————97—————>				
20	Full Supply factor proposed when channels remodelled in 1905—09.	Remodelling, records ...	<—————170—————>				
21	Full Supply factor from present working figures.	Line 3+line 22 ...	185	163	220	170	62
22	Total sanctioned discharge of distributaries ..	S. Statement, 1912-13 ..	2,218	1,054	277	715	245
23	Mean discharge on Number of days, in crop. { Kharif ... { Rabi ...	S. Statement, av. 1911-14	1,164	516	120	359	87
24		Ditto	1,318	566	170	396	27
25	Capacity factor, Kharif ...	Line 23+ line 22 ..	·52	·49	·40	·50	·35
26	" " Rabi ...	Line 24+ line 22	·59	·54	·60	·56	·11
27	Duty, Kharif ...	Line 9 +line 23' ...	148	130	160	125	118
28	" " Rabi ...	Line 12 + line 24 ...	273	261	238	224	498
29	Full Supply factor, Kharif ...	Line 9+line 22 ...	78	64	76	63	41
30	" " " Rabi ...	Line 12+line 22 ...	162	140	146	124	55
31	" " " Both crops ...	Line 29+line 30	240	204	216	187	96
32	Rainfall mean 3 years, Kharif ..	S. Statement, av. 1911-14	7·4	7·1	10·4	9·9	12·2
33	" " " Rabi ...	Ditto	2·1	2·3	2·9	2·7	3·4

February 1919.

PROJECT.

SIRHIND AND WESTERN JUMNA CANALS FOR THE AVERAGE OF 3 YEARS 1911-14
WILL TAKE PLACE UNDER THE SUTLEJ DAM PROJECT.

CANAL PROPOSED.			WESTERN JUMNA CANAL, PROPOSED.								
WESTERN JUMNA CANAL EXISTING.											
Serial No. of item.	Sirsa Branch.		Sirsa Branch.	Hanet Branch.		Butana Branch.		Delhi Branch.		Main Branch.	
	Below junction of Tohana Branch, mile 85 to tail.	Below junction of Sirsa Feeder, miles 84-85.	Above junction of Sirsa Feeder, miles 0-34	S. State-ment, 1911.	1916 Capacity Statement.	S. State-ment, 1912.	1916 Capacity Statement.	S. State-ment, 1912.	1916 Capacity Statement.	S. State-ment, 1912.	1916 Capacity Statement.
	9	10	11	12	13	14	15	16	17	18	19
1	178,336	392,544	220,722	568,310	574,558	351,129	376,624	608,780	653,020	259,445	257,040
2	142,592	339,163	201,223	486,662	493,669	299,715	339,366	540,119	547,609	235,518	209,329
3	47,630	112,797	66,940	161,946	206,608	93,231	122,660	220,085	236,149	73,336	75,782
4	33½ %	33½ %	33½ %	...	...	...	...	...	...	...	...
5	33 %	33 %	33 %	37 %	43 %	31 %	36 %	42 %	48 %	31 %	33 %
6	61,628	133,021	68,301	216,301	...	79,268	...	167,161	...	57,092	...
7	35 %	34 %	32 %	37 %	38 %	23 %	21 %	27 %	26 %	22 %	22 %
8	43 %	41 %	34 %	44 %	45 %	27 %	28 %	31 %	31 %	24 %	27 %
9	21,974	63,751	29,180	114,733	...	41,405	...	80,178	...	24,495	...
10	12 %	16 %	13 %	19 %	20 %	12 %	11 %	13 %	12 %	9 %	9 %
11	16 %	19 %	14 %	23 %	21 %	14 %	12 %	15 %	15 %	10 %	12 %
12	30,649	69,270	39,181	101,571	...	37,793	...	86,993	...	32,604	...
13	23 %	18 %	17 %	17 %	18 %	11 %	10 %	14 %	13 %	13 %	13 %
14	28 %	20 %	19 %	21 %	21 %	13 %	11 %	10 %	16 %	11 %	16 %
15	1:18	1:109	1:13	1:09	...	1:091	...	1:11	...	1:13	...
16	<-----180----->										
17	<-----182----->										
18	<-----95----->										
19	<-----10----->										
20	<-----150----->										
21	139	145	153	138	171	142	149	142	140	158	149
22	341	778	445	1,313	1,207	658	820	1,588	1,622	465	530
23	191	468	210	980	...	380	...	783	...	263	...
24	183	313	158	500	...	221	...	539	...	193	...
25	.55	.59	.49	.75	.82	.51	.49	.49	.48	.57	.50
26	.53	.44	.35	.45	.49	.34	.27	.34	.33	.41	.36
27	115	139	138	116	...	109	...	102	...	93	...
28	217	202	248	170	...	169	...	161	...	169	...
29	64	86	66	87	95	63	51	50	49	53	46
30	105	83	88	77	84	57	46	55	54	70	61
31	179	170	154	164	179	120	97	105	103	123	107
32	8.2	11.0	14.8	10.8	...	13.5	...	14.5	...	17.8	...
33	1.5	2.0	2.1	2.5	...	3.1	...	2.6	...	3.4	...

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SUTLEJ DAM PROJECT.

TABLE OF VALUES FOR "C" FOR LINED CHANNELS IN FORMULA $V = C \sqrt{R \cdot S}$.
N=0.015.

Hydraulic mean Radius feet.	Slope $\frac{1}{1}$															
	1,250	1,500	2,000	2,500	3,000	3,333	3,750	4,000	4,500	Slope $\frac{1}{5,000}$	Slope $\frac{1}{6,000}$	Slope $\frac{1}{6,666}$	Slope $\frac{1}{7,000}$	Slope $\frac{1}{7,500}$	Slope $\frac{1}{8,000}$	Slope $\frac{1}{10,000}$
1.0	98.7	98.5	98.4	97.8	97.6	97.5	97.0	96.9	96.5	96.4	95.6	95.1	94.8	94.6	94.3	93.1
2.0	112.2	111.8	111.9	111.6	111.5	111.6	111.3	111.2	111.1	111.0	110.6	110.4	110.1	110.2	109.9	109.6
3.0	119.2	119.1	119.2	119.1	119.1	119.3	119.1	119.2	119.1	119.2	119.0	118.9	118.8	118.9	118.8	118.7
4.0	123.7	123.8	124.0	124.1	124.2	124.3	124.3	124.4	124.4	124.6	124.6	124.7	124.7	124.8	124.9	125.0
5.0	127.0	127.3	127.6	127.7	127.9	128.1	128.1	128.2	128.3	128.6	128.7	128.9	128.9	129.1	129.3	129.7
6.0	129.8	129.9	130.3	130.5	130.7	131.0	131.0	131.2	131.3	131.7	132.0	132.2	132.3	132.5	132.8	133.5
7.0	131.7	132.1	132.5	132.7	133.1	133.3	133.4	133.7	133.8	134.3	134.6	134.5	135.1	135.3	135.6	136.5
8.0	133.6	133.9	134.3	134.6	135.0	135.3	135.4	135.7	135.9	136.4	136.8	137.2	137.9	137.7	138.0	139.0
9.0	135.2	135.4	135.9	136.2	136.6	137.0	137.1	137.4	137.6	138.2	138.7	139.1	139.3	139.7	140.0	141.2
10.0	136.5	136.7	137.2	137.6	138.0	138.4	138.6	138.9	139.2	139.7	140.3	140.8	140.9	141.4	141.7	143.1
11.0	137.5	137.9	138.4	138.8	139.3	139.7	139.9	140.2	140.6	141.1	141.7	142.3	142.6	142.9	143.3	144.8
12.0	138.7	138.8	139.5	139.8	140.3	140.8	141.0	141.3	141.7	142.2	143.0	143.6	143.8	144.3	144.7	146.3

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Sirhind Project Division.

The 17th April 1917.

SUTLEJ DAM PROJECT.

CAPACITY STATEMENT OF ABOHAR BRANCH.

Reduced distance of reach.	Height of fall, feet.	CANAL DIMENSION.			Re-modelled capacity, cusecs.	WETTED PERIMETER AND AREA.		Absorption at 8 cusecs per million.	DRAW OFF.					CAPACITY REQUIRED, CUSHS.	
		Bed width feet.	I. S. Depth, feet.	Bed slope 1 in.		Perimeter, feet.	Area in millions, sq. ft.		Distributaries.	Irrign. % sanctioned.	% as working distys. 1911-13.	% mean of 3 years, 1911-13.	Sanctioned discharge, in cusecs.	Kharif.	Rabi.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Tail 629,435 to fall 664,000 SARAWAN.	4.5	(22) 22	(6.5) 6.0	6,260	(528) 225	35.4	2.32	18.6	PANJAWA ...	50	50	75	187	206	206
To fall 637,650	2.18	(22) 30	6.6	5,714	580	41.7	1.17	9.6	Sarawan ... Aspal ... MALUKPUR	45 50 40	45 50 40	52 66 48	34 43 296	588	588
To fall 495,000	3	(22) 30	(6.5) 6.6	5,714	(528) 580	41.7	1.01	15.2	KARANGARH	40	40	72	50	653	653
To fall 455,000	3	(21) 35	(6.5) 7.6	5,714	(726) 860	52	2.08	16.6	ALAMWALA ARNIWALA ...	40 40	40 40	67 48	67 343	1,085	1,085
To weir 430,100	1.9	(20) 35	7.6	4,000	850	52	1.29	10.4	Kaonj A-abahur ...	40 40	40 40	78 35	7 12	1,114	1,114
To fall 404,000 Nawalnari.	4	(26) 35	7.6	5,882	850	52	1.36	10.9	...	...	...	...	...	1,125	1,125
To fall 360,000 SIBIAN.	6.5	(30) 45	(6.5) 7.6	5,882	(591) 1,360	62	2.73	21.8	RUPANA DODA ...	40 40	40 40	76 61	140 109	1,395	1,395
To fall 332,000 SMALSAR.	6	(36) 63	(7.4) 7.6	5,882	(1,059) 1,562	70	1.96	15.7	KOT KAPURA JAITU ...	40 40	40 40	61 48	76 221	1,708	1,708
To fall 289,000 CHANOWAL.	8	(38) 68	(7.4) 7.6	6,250	(1,163) 1,717	75	3.23	25.8	FARIDKOT	40	40	55	149	1,882	1,882
To fall 251,000 GHOLIA.	8	(42) 62	(7.4) 7.6	6,250	(1,273) 1,957	79	2.77	22.1	SIBIAN Datawal ... MARI ...	40 40 40	40 40 40	54 51 44	55 8 87	2,054	2,054
To S. N. C. Head 240,635.	...	(50) 84	7.85	6,250	2,303	101.6	1.36	10.9	RAOTA BAGA ...	40 40	40 40	61 51	175 79	2,319	2,319
To fall 213,000 DAOBHAR.	10	(50) 80	(7.4) 7.85	6,666	(1,463) 2,390	97.5	2.69	21.6	S. N. C. for Dhulkote.	40	40	50	76	2,417	2,417
To fall 180,000 DALA	6	(66) 86	(7.4) 7.85	6,666	(1,903) 2,437	102.5	3.38	27.1	Wadni ...	40	37	24	21	2,465	2,465
To fall 167,000 AKALLA.	6	(74) 90	(7.4) 7.7	6,666	(2,061) 2,451	107.2	2.47	19.7	Dangian ...	40	37	40	6.5	2,491	2,491
To fall 128,000 TUGHIAL.	8	(76) 95	7.65	6,666	2,657	112.1	3.25	20	Akhara JAGRAON ...	40 40	32 33.5	32 39	23.17 165	2,705	2,705
To fall 105,000 AKALGARH.	8	(76) 95	(7.4) 7.9	6,666	(2,116) 2,765	112.6	2.59	23.7	MANOKI ...	40	33	29	62	91	2,791
To fall 695,000 BALLOWAL.	8	(82) 84	(7.4) 8	6,666	(2,298) 2,820	101.9	3.62	28.0	Akalgarh (K) .. Jassowal (K)...	16 16	12 13	29 19	7 37.4	2,864	2,820
To fall 47,000 CHUPKI.	8	(81) 86	(7.4) 8	6,666	(2,364) 2,880	103.9	2.34	18.6	Ballowal (K) TALWANDI(K)	16 16	11 10	20 15	6.14 50	2,939	2,838
To fall 23,000 KHANPUR.	8	(96) 100	(7.4) 8	6,666	(2,129) 2,906	117.9	2.83	22.6	Chupki (K) ...	16	17	7	2.5	2,964	2,901
HEAD	...	(88) 130	(7.4) 8	6,666	(2,560) 3,025	117.9	2.71	21.7	KHANPUR R	16	13	22	62.5	3,048	2,883
387									2,661						

NOTE.—Figures in italics denote original design.
K. signifies kharif disty.

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Sirhind Project Division.

The 23rd January 1917.

SUTLEJ DAM PROJECT.

CAPACITY STATEMENT OF BHATINDA BRANCH.

Reduced distance of reach.	Height of fall feet.	CANAL DIMENSION.			Remodelled capacity, cusecs.	VERTED PERIMETER.		Absorption at 8 onsees per million.	DRAW OFF					CAPACITY REQUIRED, CUSECS.	
		Bed width, feet.	F. S. depth, feet.	Bed slope 1 in.		Perimeter, ft.	Area in millions sq. ft.		Distributaries	Irrig. % sanctioned.	As working condition 1911-13.	% of three years 1911-13.	Sanctioned discharge in cusecs.	Kharif	Rabi.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Tail 500,000 to fall 448,000 (TEONA).	3	(24) 34	(6) 5.7	5,714	(553) 400	46.7	2.12	10	LAL BHAI ... LAMBH ... Jangirana ...	43 40 38	40 36 30	52.1 43.7 56.1	185 250 11	465	465
To fall 411,829 BHATINDA.	6	(30) 42	(6) 5.7	5,714	(655) 634	54.7	2.0	16	TEONA ...	33	30	32.8	162	643	643
To fall 390,000 BIBIWALA.	5	(30) 43	(6) 5.1	5,000	(655) 642	51.3	1.15	9	BHATINDA ... BHAIMAN ...	33 33	30 30	37.3 43	91 79	822	822
To weir 377,000	...	(36) 43	(6) 5	5,000	(768) 817	56.3	.73	6	...	...	...	...	...	828	828
To fall 350,500 POOHLA.	5	43	6.7	5,000	990	57.9	1.53	12	KOT BHAI ...	33	30	39.9	168	1,003	1,003
To fall 307,000 SADHANA.	8	(42) 46	(7.4) 6.7	5,714	(1,273) 1,010	60.9	2.64	21	...	...	...	...	...	1,024	1,024
To fall 277,000 BALLOKI.	8	(50) 54	(7.4) 6.4	6,250	(1,463) 1,039	68.2	2.04	18	Mari ...	33	30	43.1	15	1,055	1,055
To fall 221,750 TALLEWAL.	6	(54) 56	(7.4) 7	6,250	(1,537) 1,275	71.6	3.95	31	PHUL ...	33	30	34.6	203	1,294	1,294
To fall 185,000 CHAK BHAI.	9.5	(58) 61	(7.4) 5.5	6,250	(1,698) 1,561	77.7	2.35	23	DHIPALI ... BHADAUR ...	33 33	30 30	40.8 34.5	97 169	1,533	1,533
To fall 155,500 DADAHUR.	6	(62) 62	(7.4) 8	6,250	(1,810) 1,730	79.8	2.35	19	Gahil ... SEHNA ...	...	33 30	33 31.4	9 122	1,733	1,733
To fall 128,000 LOHGARH.	8	(66) 75	(7.4) 7.4	6,250	(1,903) 1,752	91.4	2.51	20	Kalas ...	33	25	23	18	1,771	1,771
To fall 109,000 MAHOLI.	6	(72) 82	(7.4) 7.4	6,250	(2,068) 1,871	98.4	1.87	15	RAEKOT ...	33	25	25	101	1,837	1,837
To fall 85,250 KANGANWALA.	10	(74) 90	(7.4) 7.4	6,666	(2,061) 1,970	106.4	2.52	20	KALLIAN ...	33	21	21	87	1,994	1,994
To fall 58,900 JAGHERA.	8	(76) 90	(7.4) 7.5	6,666	(2,116) 1,993	106.7	2.81	22	Maholi ...	33	17.5	19	11	2,027	2,027
To fall 32,250 KHATRA.	8	(82) 100	(7.4) 7.1	6,666	(2,203) 2,014	115.8	3.08	25	Pohir K ...	16	16	21	3	2,055	2,052
HEAD	...	(84) 100	(7.4) 7.1	8,666	(2,364) 2,062	115.8	8.73	30	Dehlon K. ...	16	11.5	13	33	2,118	2,082
													1,814		
														304	

NOTE.—Figures in italics denote original design.
K. Signifies Kharif Disty.

1st 23rd January 1917.

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SUTLEJ DAM PROJECT.**LOWER SIRHIND CANAL.****LIST OF DRAWINGS IN FOLIO.****ALI WAL HEADWORKS.**

Serial No.	Heading.	Scale.
HEADWORKS.		
1	Map of River Sutlej below Phillour showing Aliwal Headworks (2 sheets) ...	4" = 1 mile
2	General Plan of Headworks ...	1/1000
3	Plan of Pocket, Head Regulator, Sluices and Divide Wall ...	1/400
4	Plan of Regulator ...	1/100
5	Cross Section of Weir ...	1/100
6	Cross Section of Under Sluices ...	1/100
7	Plan and section of Junction of Weir with Undersluices and Details of Fish Ladder ...	1/100
8	Plan and section of Right Flank of Weir ...	1/100
TRAINING WORKS.		
9	Long. Section of Upstream Left Marginal Bund and Budha Nahn Diversion ...	H 1" = 1 mile V 1/100
10	Regulator for Budha Nahn in Upstream Marginal Bund at R.D. 1,000 ...	1/100
11	Plan of Upstream Left Guide Bank ...	1/1000
12	Do. do. Right Spur ...	1/1000
13	Do. do. Right Guide Bank... ...	1/1000
14	Plan of Downstream Right Guide Bank... ...	1/1000
15	Do. do. Right Spur ...	1/1000
SECTIONS OF RIVER.		
16	Long. Section of River Sutlej showing surface slope from Phillour to Sidhwan ...	H 1" = 1 mile V 1/100
17	Long. Section of River Sutlej at site of Headworks showing River water surface and bed levels ...	1/25000
18-19	Cross Sections of River Sutlej, 1, 2, 4 and 5, selected sections, 2 sheets ...	} H = 1/20000 V = 1/200
20-26	Cross Sections of River Sutlej, I to XXI on Riverain Survey Crosses, 7 sheets ...	

SUTLEJ DAM PROJECT.**LOWER SIRHIND CANAL.****LIST OF DRAWINGS IN FOLIO.****MAIN CANAL AND BRANCHES.**

Serial No.	Heading.	Scale.
MAIN LINE.		
1	Index plan of alignment	1" to 1 mile.
2	Longitudinal section	Hor. 1" = 1 mile. Ver. 1/100
3	Typical sections	1/200
4	Syphon for Budha Nala, R. D. mile 2—1,000 feet	1/200
5	Regulators for Main Line Lower and Grey Canal Feeder, R. D. mile 8—4,000 feet	1/200
6	Village road bridge and aqueduct for Jagraon Distributary, R. D. mile 21—136 feet	1/100
7	Village road bridge and aqueduct for Daudhar Distributary, R. D. mile 24—2,655 feet	1/100
8	Regulators at tail for Abohar Branch and Abohar-Bhatinda Feeder	1/100
GREY CANAL FEEDER.		
9	Index plan of alignment	1" to 1 mile.
10	Longitudinal section	Hor. 1" = 1 mile. Ver. 1/100
11	Map showing irrigation, 1915	1" to 1 mile.
ABOHAR-BHATINDA FEEDER.		
12	Index plan of alignment	1" to 1 mile.
13	Longitudinal section	Hor. 1" = 1 mile. Ver. 1/100
14	Typical sections	1/200
15	Drainage inlet at R. D. mile 2—2,000 feet	1/100
16	Village road bridge and aqueduct for Bhadaur Distributary, R. D. mile 17—500 feet	1/100
17	Village road bridge and aqueduct for Dhipali Distributary, R. D. mile 22—2,333 feet	1/100
18	Regulators at tail for Bhatinda Branch and Phul Feeder	1/200
PHUL FEEDER.		
19	Index plan of alignment and longitudinal section	1" to 1 mile.
20	Typical sections	1/200
21	Regulators at tail for Rori (A. 9) and Bhatinda-Bikaner Feeders	1/200
RORI (A-9) FEEDER.		
22	Index plan of alignment	1" to 1 mile.
23	Longitudinal section	Hor. 1" = 1 mile. Ver. 1/100
24	Typical sections	1/200
25	Syphon for Kotla Branch, R. D. mile 17—523 feet	1/200
26	Syphon for Sandoha Branch, R. D. mile 19—200 feet	1/100
27	Regulating Bridge and Head Regulator for Chautala Distributary, R. D. mile 28—4,000 feet	1/100
BHATINDA-BIKANER FEEDER.		
28	Index plan of alignment	1" to 1 mile.
29	Longitudinal section	Hor. 1" = 1 mile. Ver. 1/100
30	Typical sections	1/200
31	9 feet Fall and village road Bridge at R. M. R. Crossing	1/100
32	Regulators at tail for Bikaner Border Branch and Bikaner Main Branch	1/200
BIKANER BRANCHES.		
33	Index plan of alignments	1" to 1 mile.
34	Longitudinal section, Main Branch	Hor. 1" = 1 mile. Ver. 1/100
35	Typical sections, Main Branch	1/200
36	Longitudinal section and Typical section, Border Branch	Hor. 1" = 1 mile. Ver. 1/200

SUTLEJ DAM PROJECT.

LOWER SIRHIND CANAL.

APPENDIX D.

STATEMENTS AND EXTRACTS REGARDING THE GREY CANALS.

Serial No.	Description.	Page No.
1	Statement showing the details of the Head Reaches of the Grey Canals ...	156
2	Statement of dates of opening and closing of Ferozepore Grey Inundation Canals from 1906-07 to 1915-16	157
3	Abstract statement shewing the earliest and latest dates of opening and closing of the Grey Canals above Ferozepore	158
4	Statement giving details of maximum and minimum areas irrigated by the Grey Canals	159
5	Abstract statement of areas sown and matured on the eight Grey Canals taking off from the Sutlej above Ferozepore and details of areas by tchsils	160
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7	Correspondence regarding Grey Canals in 1911	163-165
8	Extracts from the Report by Mr. Currie, Settlement Officer, Ferozepore, in 1913, on the condition and future management of the Grey Canals of the Ferozepore District	166-168
9	Copy of a petition, dated 15th January 1917, from the Zamindars of certain villages in the Grey Canals tract asking for irrigation from the Sirhind Canal	170
10	Copy of a letter No. 270, dated 22nd November 1916, from the Superintendent, Grey Canals, to the Executive Engineer, Project Division, Sirhind Canal, regarding the new scheme	171
11	Wajab-ul-arz (Records of rights and obligations) for Grey Canals, Ferozepore District	172-173

STATEMENT SHOWING THE DETAILS OF THE HEAD REACHES OF THE GREY CANALS.

Name of Canal.	Bed Width, feet	R. L. of Bed.	F. S. Depth, feet.	Bed Slope.	F. S. Dis-charge.	REMARKS.
					Cusecs.	
Kingwah	45	735.00	4.5	1/10,000	350	
Aghawah	70	727.50	4.7	1/5,000	848	The parent channel of Ilahi-wah and Daulatwah Canals.
Ilahiwah	40	711.00	5.0	1/10,000	375	Distributary of Aghawah Canal
Daulatwah	30	715.80	4.5	1/10,000	215	Ditto ditto.
Bacherawah	40	713.00	5.0	1/10,000	360	
Barneswah	45	698.50	5.0	1/5,000	590	The parent channel of Mayn-wah and Butawah Canals.
Mayawah	25	684.30	4.6	1/2,500	390	The parent channel of Butawah Canal.
Butawah	30	665.75	3.6	1/6,666	195	Distributary of Mayawah Canal.
Capacity of Canals to be fed from Sutlej Dam Project ...					2,148	
Jalalwah	45	637.00	5.4	1/10,000	475	
Nizamwah	60	630.00	8.0	1/10,000	1,225	The parent channel of Qutab-wah and Khanwah Canals.
Khanwah	20	620.50	4.7	1/10,030	160	Distributary of Qutabwah Canal.
Qutabwah	35	623.30	5.0	1/6,666	390	The parent channel of Khan-wah Canal.
Punjewah	50	611.00	5.0	1/10,000	460	
Mubarikwah	60	600.00	5.0	1/10,000	560	
Fazilwah	50	587.00	5.0	1/10,000	460	
Capacity of Canals below Ferozopore to be fed from the Lower Sutlej Valley Project.					3,180	
Total capacity of all Canals					5,328	

- STATEMENT OF DATES OF OPENING AND CLOSING OF FEROZEPURE GREY INUNDATION CANALS FROM 1906-7 TO 1915-16.

Serial No.	Name of Canal.	1906-07.		1907-08.		1908-09.		1909-10.		1910-11.		1911-12.		1912-13.		1913-14.		1914-15.		1915-16.	
		Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.
1	Kingwah	9-5	30-9	26-5	24-8	7-5	20-9	16-6	19-9	3-6	23-9	11-6	5-9	2-5	20-9	26-5	6-9	23-5	26-9	16-5	2-10
2	Aghawah	27-5	1-9	16-6	28-9	17-5	26-9	1-6	3-10	29-5	8-10	1-6	25-9	16-5	21-9	15-5	16-9	27-5	30-9	17-5	2-10
3	Ilahiwah	2-6	30-9	12-6	5-10	13-5	29-9	1-6	2-10	27-5	13-10	4-6	27-9	12-6	21-9	15-5	10-9	28-5	30-9	16-5	20-9
4	Gaulatwah	1-6	8-10	10-7	23-9	18-5	2-10	1-6	2-10	26-5	11-10	11-6	23-9	11-5	18-9	14-5	12-9	27-5	30-9	26-5	2-10
5	Bacherewah	28-4	30-9	3-6	19-9	10-5	17-9	1-6	1-10	5-6	8-10	1-6	30-9	28-1	21-9	20-5	13-9	28-5	29-9	6-6	30-9
6	Barneswah	18-5	25-8	15-6	12-9	23-5	4-10	1-6	19-9	6-6	20-9	1-6	25-9	21-1	1-10	14-5	11-9	15-5	30-9	18-5	15-10
7	Mayawah	2-6	30-9	10-6	21-8	7-6	13-9	1-6	11-9	7-6	17-9	1-6	27-9	20-1	1-10	14-5	16-8	15-5	30-9	18-5	15-10
8	Butawah	17-5	30-9	10-6	13-9	28-4	25-9	1-6	1-10	30-5	17-9	1-6	5-10	30-1	17-9	22-5	12-9	15-5	30-9	19-5	15-10
9	Jalalwah	1-6	4-10	15-6	1-10	27-4	3-10	3-6	3-10	1-6	4-10	1-6	30-9	19-5	20-9	18-5	7-9	9-5	30-9	14-5	30-9
10	Nizamwah	1-6	15-10	27-5	21-8	29-4	1-10	30-6	26-9	21-6	17-9				31-10	22-5	25-9	17-5	3-10	21-5	10-10
11	Khanwah	4-6	25-9	27-5	21-8	29-4	1-10	30-6	26-9	28-6	13-9				18-10	27-5	21-9	17-5	26-9	25-5	9-19
12	Qutabwah	10-5	30-9	12-6	20-9	12-4	16-9	26-1	26-9	21-6	17-9				18-10	27-5	28-9	17-5	2-10	21-5	9-10
13	Punjewah	29-5	20-10	2-6	20-8	20-5	4-10	4-6	2-10	21-6	30-9				5-10	23-5	20-9	7-5	3-10	22-5	2-10
14	Mubarikwah	5-5	30-9	19-6	15-9	15-5	11-9	13-6	22-9	3-6	28-9	1-6	7-10	21-1	5-10	26-5	24-9	7-5	3-10	16-5	9-10
15	Fazilwah	1-6	15-10	30-5	30-9	30-1	11-10	2-5	3-10	29-6	1-10	22-6	20-9	3-5	30-9	26-5	30-9	7-5	30-9	16-5	9-10

Not available.

Notz.—No. 1 to 8 take off from Sutlej above Ferozepore and will be fed from the Sutlej Dam Project.

ABSTRACT STATEMENT SHOWING THE EARLIEST AND LATEST DATES OF
OPENING AND CLOSING OF THE GREY CANALS ABOVE FEROZEPORE.

Year.	DATE OF OPENING.		DATE OF CLOSING.		Date of Sirhind Canal closure.
	Earliest.	Latest.	Earliest.	Latest.	
1906-07	25th April	2nd June	25th August	5th October	20th April.
1907-08	6 May	16th June	24th August	5th October	27th April.
1908-09	25th April	7th June	17th September	2nd October	20th April.
1909-10	1st June	16th June	11th September	3rd October	21st April.
1910-11	26th May	7th June	17th September	13th October	Nil.
Bhakra discharge	25,000	35,000			
1911-12	1st June	11th June	7th September	5th October	20th March.
Bhakra discharge	50,000	40,000			
1912-13	20th April	12th June	17th September	4th October	11th April.
Bhakra discharge	16,000	27,000			
1913-14	14th May	26th May	12th August	10th August	20th May.
Bhakra discharge	17,000	20,000			
1914-15	12th May	25th May	27th September	30th September	Nil.
Bhakra discharge	22,000	27,000			
1915-16	16th May	26th May	20th September	15th October	11th April.
Bhakra discharge	26,000	20,000			
Mean	15th May	6th June	6th September	4th October.	
Mean	25th May.		21st September.		
Bhakra discharge 6 years average on date two days before date above.	19,000 cusecs.		22,000 cusecs.		

The discharges at Bhakra are those two days prior to the date given for opening the Canals.

**STATEMENT GIVING DETAILS OF MAXIMUM AND MINIMUM AREAS IRRIGATED
BY THE GREY CANALS.**

Name of Canal.	Length in Miles.	Commanded area, acres.	MAXIMUM AND MINIMUM AREAS IRRIGATED BETWEEN 1899-00 AND 1910-11.			
			Maximum, acres.	Year.	Minimum, acres.	Year.
Above Ferozepore to be fed from Sutlej Dam Project.						
Kingwah	29	29,979	13,225	1900-07	3,593	1907-08
Aghawah	30	19,200	49,907	1900-01	4,923	1910-11
Ilahiwah	29	47,914			13,691	1910-11
Daulatwah	40	24,030	14,147	1909-01	3,375	1910-11
Bacherwah	42	21,113	20,648	1900-01	5,483	1910-11
Barneswah	37	18,484	15,172	1906-07	3,198	1901-02
Mayawah	40	18,083	10,241	1900-01	2,528	1907-08
Butawah	28½	17,612	9,986	1906-07	4,394	1910-11
Total	...	196,295	132,426	...	41,385	...

Below Ferozepore.

Jalalwah ...	40	47,746	32,798	1906-07	6,820	1899-00
Nizamwah ...	45	57,078	39,518	1905-06	10,230	1907-08
Khanwah ...	25	19,372	11,312	1906-07	1,687	1910-11
Qutabwah ...	32	18,960	11,126	1906-07	2,615	1899-00
Panjewah ...	45	24,901	18,993	1900-01	5,662	1907-08
Mubatikwah ...	39	33,229	32,053	1900-01	2,396	1904-05
Faralwah ...	28	26,618	18,970	1900-01	3,773	1902-03
Total ...	...	227,033	163,878	...	33,063	...
Total of all Canals ...	...	424,288	296,304	...	74,468	...
Maximum and minimum in any one year all canals being taken to- gether.	...	..	270,310	1906-07	97,201	1901-11

Maximum and minimum areas irrigated between 1912-13 to 1916-17.

Kingwah ...	...	...	8,835	1914-15	3,540	1913-14
Aghawah ...	...	...	9,905	1914-15	4,542	1915-16
Ilahiwah ...	...	...	18,683	1914-15	10,037	1915-16
Daulatwah ...	...	...	6,077	1914-15	3,220	1912-13
Bacherwah ...	...	...	11,911	1913-14	6,529	1915-16
Barneswah ...	...	...	8,900	1913-14	4,916	1916-17
Mayawah ...	...	...	11,527	1913-14	4,465	1916-17
Batawah ...	...	...	9,031	1914-15	4,068	1916-17
Total ...	...	...	82,969	...	41,547	...
Full Supply Factor ...	...	...	39	...	19	...
Maximum and minimum in any one year of 8 canals above Ferozepore.	...	...	78,245	1914-15	48,870	1915-16
Full Supply Factor ...	...	...	36	...	23	...

**ABSTRACT OF AREAS SOWN AND MATURED ON THE EIGHT GREY
CANALS TAKING OFF FROM THE SUTLEJ ABOVE FEROZEPORE.**

Year.	Kharif Area in Acres.		Rabi Area in Acres.		Total Area in Acres.	
	Sown.	Matured.	Sown.	Matured.	Sown.	Matured.
1912-13	31,177	25,182	23,072	17,187	54,199	42,369
1913-14	34,949	27,809	27,152	21,740	62,094	49,549
1914-15	40,740	35,520	37,805	30,980	78,345	66,500
1915-16	34,803	31,872	14,287	11,108	48,870	42,978
1916-17	37,091	33,479	14,276	10,538	51,367	44,017
Total ..	178,803	153,862	116,372	91,551	294,875	245,413
Mean	35,701	30,778	23,274	18,310	58,975	49,083
Percentage ... ..	...	86.2	...	78.67	...	83.22
Full Supply Factor	16.6	14.3	10.8	8.5	27.4	22.8

**STATEMENT SHOWING TOTAL GROSS AREA AND AREA IRRIGATED ON THE
EIGHT CANALS BY TEHSILS, ABSTRACTED FROM THE RECORDS
OF THE GREY CANALS FOR THE YEAR 1914-15.**

Tehsil.	Gross area, acres.	Total area irrigated, acres.	Percentage.
Zira	228,608	38,241	16.73
Ferozepore	117,316	21,887	18.65
Moga	76,888	14,879	19.33
Total ...	422,812	75,007	...

NOTE — Total gross area taken in Sutlej Dam Project = 425,000 acres.

STATEMENT SHOWING AREAS SOWN AND MATURED ON THE EIGHT
GREY CANALS TAKING OFF FROM THE SUTLEJ ABOVE
FEROZEPORE.

1912-13.

Canals.				Kharif Area in Ghumaon.		Rabi Area in Ghumaon.		Total Area in Ghumaon.		Total Area in Acres	
				Sown.	Matured.	Sown.	Matured.	Sown.	Matured.	Sown.	Matured.
Kingwah	...	...	...	3,322	3,247	1,972	1,933	5,294	5,180	4,412	4,317
Aghawah	...	...	...	4,025	3,658	3,709	3,105	7,734	6,761	6,445	5,634
Ilahiawah	...	...	...	5,259	5,152	7,045	6,854	12,304	11,806	10,253	9,838
Daulatwah	...	...	...	2,058	1,600	1,776	1,265	3,834	3,065	3,220	2,571
Bacherawah	...	...	...	7,444	6,005	3,181	2,776	10,625	8,781	8,854	7,317
Barneswah	...	...	...	5,221	3,896	3,217	1,744	8,438	5,640	7,032	4,700
Mayawah	...	...	...	4,755	3,475	3,875	1,870	8,630	5,045	7,182	4,204
Butawah	...	...	...	5,238	2,988	2,911	1,557	8,149	4,545	6,781	3,788
Total	In ghumaon	...	...	37,352	30,219	27,686	20,624	65,038	50,843	...	...
	In acres	...	...	31,127	25,182	23,072	17,187	...	...	54,169	42,369

1913-14.

Kingwah	...	...	...	2,965	2,824	1,283	1,145	4,248	3,969	3,540	3,307
Aghawah	...	...	...	4,797	3,973	3,424	2,956	8,221	6,929	6,851	5,774
Ilahiawah	...	...	...	7,230	6,845	4,821	4,060	12,051	10,925	10,042	9,104
Daulatwah	...	...	...	3,400	2,601	1,952	1,628	5,352	4,229	4,460	3,524
Bacherawah	...	...	...	8,705	6,848	5,498	4,767	14,203	11,635	11,911	9,606
Barneswah	...	...	...	6,004	4,255	4,676	3,231	10,680	7,486	8,000	6,238
Mayawah	...	...	...	4,017	3,437	9,156	6,748	14,073	10,183	11,727	8,486
Butawah	...	...	...	3,523	2,588	1,773	1,516	5,296	4,104	4,663	3,420
Total	In ghumaon	...	...	41,931	33,371	32,583	26,038	74,514	59,460	...	...
	In acres	...	...	34,942	27,809	27,152	21,740	...	...	62,094	49,540

1914-15.

Kingwah	...	...	...	6,665	6,381	3,937	3,637	10,602	10,219	8,835	8,515
Aghawah	...	...	...	5,482	4,760	5,324	3,675	10,806	8,435	9,005	7,029
Ilahiawah	...	...	...	11,458	11,104	8,442	8,358	19,900	19,462	16,583	16,218
Daulatwah	...	...	...	4,404	3,761	3,969	3,674	8,373	7,435	6,977	6,196
Bacherawah	...	...	...	8,202	6,885	4,873	4,519	13,075	11,404	10,896	9,501
Barneswah	...	...	...	4,293	3,739	5,753	4,592	10,046	8,331	8,372	6,943
Mayawah	...	...	...	4,128	3,058	6,247	4,541	10,375	7,599	8,646	6,333
Butawah	...	...	...	4,256	2,937	6,560	3,980	10,836	6,917	9,031	5,765
Total	In ghumaon	...	...	49,868	42,625	45,123	37,176	94,013	79,601	...	...
	In acres	...	...	40,740	35,520	37,605	30,960	...	...	78,345	66,500

1915-16.

Canals.	KHARIF AREA IN ACRES.		RABI AREA IN ACRES.		TOTAL AREA IN ACRES.	
	Sown.	Matured.	Sown.	Matured.	Sown.	Matured.
Kingwah	4,744	4,728	1,488	1,339	6,232	6,068
Aghawah	3,684	3,839	1,058	734	4,742	4,073
Ilahiawah	7,538	7,413	2,400	2,099	10,037	9,512
Daulatwah	3,944	3,496	615	427	4,559	3,923
Bacherewah	5,160	4,751	1,340	987	6,500	5,738
Barneswah	3,652	3,499	2,009	2,136	5,661	5,635
Mayawah	2,791	2,332	2,643	1,996	5,434	4,328
Butawah	2,861	2,293	2,015	1,388	4,876	3,681
Total	34,603	31,872	14,267	11,106	48,870	42,978

1916-17.

Kingwah	5,905	5,953	2,214	1,970	8,179	7,923
Aghawah	3,765	3,405	2,152	1,378	5,917	4,783
Ilahiawah	9,019	7,950	2,914	2,514	10,933	10,464
Daulatwah	2,843	2,459	1,208	817	4,051	3,276
Bacherewah	6,577	5,641	2,231	1,789	8,808	7,430
Barneswah	3,652	3,008	1,294	668	4,946	3,676
Mayawah	3,205	2,572	1,260	817	4,465	3,389
Butawah	3,065	2,258	1,003	581	4,068	2,839
Total	37,081	33,479	14,270	10,538	51,351	44,017

CORRESPONDENCE REGARDING GREY CANALS IN 1911

Copy of a letter No. 741, dated 16th February 1911, from B. N. Bosworth Smith, Esquire, Deputy Commissioner, Ferozepore, to the Superintending Engineer, Sutlej Valley Irrigation Project.

1. The Grey Canals, fifteen in all, have been aligned for the most part unscientifically and wrongly. Consequently silting operations are very costly each year and increasingly so.

2. It is my firm opinion that owing to water-logging and the wasteful flooding of land the actual value of the land irrigated has deteriorated. Certainly large tracts have gone out of cultivation, and there can be no doubt that much harm has been done in the past through the failure to control and regulate the water-supply, and the whole face of the country has much changed during the last twenty years, where too much water has been given.

3. Management is a continuing difficulty, and should certainly now come under departmental management.

The Deputy Commissioner is heavily worked, and unless he attends to matters, things are apt to be shirked.

The above are to my mind three very cogent reasons for taking over this tract from the Harike weir, if it is financially possible.

4. I think it is. I think no question of compensation would arise or should be raised. As the Project matures the Grey Canals should be gradually let to drift, and when the scientific system once comes into force, the Zamindars will be quick enough to see its benefits and take its water.

I think that for the first five years after starting no increase in revenue should be taken, and this would be a tacit recognition on the part of Government that it has done very well from the Grey Canals in the past, getting, as clear profit without any responsibility, nearly a lakh of rupees yearly. After five years I think the rates might be raised 25 per cent, and would then come under revision at next settlement or previously.

To refuse this opportunity of better irrigation would in my opinion be the greatest misfortune for the tract, and Government certainly would not be free from blame, as it shares the profits from the slow deterioration of the soil and is itself largely responsible for the present haphazard system of irrigation. I attach two notes from the Settlement Officer and the Superintendent, Grey Canals. I would ask to be kept informed from time to time of progress and of any decision that may be come to, as such matters affect our management and we have lately been spending big sums in re-alignment.

I would mention, that I am new to the district, and without studying all the project it is impossible to give more than a general answer and a general, albeit firm, impression.

It should be mentioned here that some part of the Jalalwah can probably be utilised in the Lew project.

It should further be added that it is eminently desirable that Government should take over the whole tract now watered by the Grey Canals, and it should be possible to do the remainder from the Sirhind Canal by Jagraon.

DEPUTY COMMISSIONER—

You ask me to let you know what I think of the fairness of the two alternative proposals mentioned by Mr. Schonemann in his demi-official of the 4th instant.

I take the first to mean that if the Irrigation Branch, Public Works Department takes over the tract now irrigated by the Grey Canals, and ignores the existence of the present channels and digs new distributaries, it will have a claim to the income now derived from "Khusliysiate" (water advantage rate) which is at present credited to Government, plus an additional 25 per cent. expected from an improved system of irrigation.

Under such circumstances, if the Zamindar pays the same water rates, as he is doing now, he has nothing to grumble at.

2. The other proposal is to charge, Imperial Canal water rates, if compensation is paid to private parties for vested interest in the existing canals.

In this case the individual share of the Zamindar will be small, and he will in further have to pay a very much higher water rate than he has hitherto been doing.

Another difficulty is, supposing the canal runs through A's land. Within this length, B takes water, and irrigates his land say a mile away. None of B's land originally came under the canal, but he has enjoyed the privilege of irrigation for years past at a very low water rate. Now, if compensation is paid, it will be paid to A. B will get nothing, and will yet have to pay about three times as much for water. This, needless to say, he will not like.

There was no arrangement made, nor were such contingencies thought of, when the canals were first dug.

Then, again, for the first 10 miles of its length, practically no irrigation is done from canal, although land coming under it in the head reach is more than at the tail. Including berms, bank and spoil, the land required may be 150 feet wide; whereas at the tail it may be only 25. A man then getting compensation in the head reach will greatly score. He will get paid more, although he gets little or no irrigation. The other man at the tail irrigates freely. The amount of compensation he will get will be small, although he will in future have to pay a much higher water rate.

For the above reasons, I do not think the irrigators as a whole will agree to the second proposal.

If, however, the Irrigation Branch intends to charge Imperial canal water rates and also takes enhanced "Khushysiate" the second proposal will be the best to agree to; otherwise, to my way of thinking, undoubtedly the first.

3. I attach a statement showing cost of original construction of all canals, subsequent additions, and present value.

I also give the amount of revenue realised from canal rates and "Khushysiate" for the ten years ending 1908-09, as well as the area irrigated.

I have not been able to show Kharif and Rabi separately as until last year water rates were collected once in the year with the Rabi instalment, and no details of Rabi and Kharif crops were recorded in this office. They are now, however, collected with the Kharif and Rabi separately. Also I am unable to give the principal crops separately, as they are not recorded in the Grey Canals office as such. If required, they can be got from the tehsils, but this will take a few days.

Dated 7th February 1910.

S. N.-HERDON,
Superintendent, Grey Canals.

DEPUTY COMMISSIONER—

You ask for my opinion on Mr. Schonemann's proposals given in his demi-official of the 4th ultimo.

There seems to be two alternative proposals—

(a) Take over the canals, as they stand, with the expectation of an immediate income of about 1 lakh, developing through better management to 1½ lakhs.

(b) Buy out the present owners and make the canals a Government thing and take higher rates.

As regards (a), from the figures given by Herdon 1 lakh seems to me too optimistic for the "Khushysiate," but I suppose the Canal Department would also take the "revenue" realized from canal rates, by which I suppose is meant the amount collected for the Grey Canal Fund to meet maintenance of establishment and silt clearance charges. Thus the income to be expected would be:—

			Rs.
Average canal rate for 10 years	...	...	1,90,573
" Khushysiate	...	...	77,968
		Total	2,68,541
Add 25 per cent. for improved management		...	67,135
			3,35,676

or taking round figures Rs. 3,36,000 per annum.

* This appears incorrect, see Secy., Civil Department's No. 1411 of 4th October 1875, also Joint Secy's Irrign. No. 2047 I of 2nd May 1878 and Appendix D. 11, para. 15.

The present average realisations for the last 10 years calculated on the average irrigated area give a rate of practically Rs. 1 6-8½ per acre irrigated.

I may further point out that in his review of the forecast report a part of 1 anna per acre is anticipated and possibly it might be held that some of the "Khushysiate" should be transferred to this head. In any case it is at present land revenue, and not canal revenue, and cesses and local rate are charged on it.

As regards (b), to take over the canals would be an extremely costly business. Mr. Herdon puts the present value of the canals as Rs. 16,49,550, but this only, as he explains, is merely the original cost of construction and cost of subsequent additions. To this would have to be added the value of the land taken up by them. Besides I believe that the majority at any rate were built by unpaid labour, and I do not know if the value of this has been included by Mr. Herdon. It would necessitate a very long inquiry to work the amount of compensation due.

Thus, in my opinion, the first alternative is to be preferred, but I may point out that I foresee some difficulty when it comes to taking up the land which would be required for remodelling and straightening the present tortuous courses of these canals as the Zamindars probably would not now-a-days, that land is so much more valuable, be prepared to give up land free, especially to a Government department.

M. M. L. CURRIE,

Dated the 13th February 1911.

Settlement Officer.

**Extracts from the Report by Mr. Currie, Settlement Officer, Ferozepore, in 1913,
on the condition and future a management of the Grey Canals of the
Ferozepore District, File No. 13, R. & A
1**

Paragraph 3.—A good idea of the methods on which these canals were dug and the resultant defects may be obtained from a perusal of the printed reports of 1875 and 1876, together with the report written by Mr. Palmer in 1875. Funds being practically non-existent, one of the great principles before the mind of the originator of the Grey Canals was economy, both in cash and in labour. Hence the canals were not aligned scientifically, but efforts were made to utilise natural channels such as the Sukkar as far as possible.

A mouth having been constructed, the water was conducted a few miles and then poured into some natural drainage channel; after running down this for some way it was held up by a dam across the channel and then taken off by a cutting. The water was left first to silt up the depression and then to carve out a channel for itself. The result was a very sinuous course, while the water lost its velocity in these depressions, and the consequence was excessive silt deposit. The maps attached to Mr. Fanshawe's report clearly show the sinuous courses adopted for these canals. To quote Colonel Grey's Manual for the construction of District Canals: "Elegance may be disregarded and economy alone kept in view. If a depression, or an old channel, however unsightly, can be found which will carry on the water free of cost for a few miles, moderate sinuosity or disproportionate size may be disregarded. In the course of years it will silt up to the dimensions of the canal, and then no critic will be aware of the makeshift. Meanwhile the depression will act as an admirable silt trap, and it will thus save much cost both in original construction and in subsequent clearance. The water should, therefore, by all means be dropped into such a depression or channel as far as it leads in the desired direction, and then taken out again by a dam. But when the point is reached where the flood level of the canal, carried down from the mouth with an average slope of say 9 inches per mile, is flush with the ground, then the highest irrigating crest obtainable, which is compatible with this flood level, must be sought for; and this can always be indicated by the people of the neighbourhood. From that point it will be the object so to carry on the canal that the average head of water shall be just within cutting."

In fact, the principal consideration kept in view, at any rate in the construction of new works, was low capital cost.

Paragraph 5.—The bed slopes of the canals was considered by Mr. Palmer to be insufficient and likely to lead of excessive silting, a forecast which has, I think, been fulfilled.

Paragraph 8.—Another contributory factor to the present bad condition of the canals has been the neglect of silt clearance in the lower reaches of the canals. While Colonel Grey was there to supply the initiative and driving force, things went well, but after he left the system under which the Zamindar did their own silt clearance broke down and the doing of work by contract was substituted. There was probably a tendency then to do only the necessary work on the upper reaches, so that the rates proposed before the annual Jalsa Bachh could be kept low. Since fixed rates were imposed in 1908, the seasons have not been very favourable, and the income has been insufficient to enable these much needed operations to be fully carried out in view of the great rise in the cost of labour in recent years.

Paragraph 12 (i).—So far the irrigation from the Kingwah has been less than half than originally anticipated. The reason of this is that out of the 52 villages in Moga and Zira tehsils that are supposed to be commanded only 28 take water. Most of the villages irrigable in the Zira tehsil have a comparatively poor command together with sandy soil, and the people prefer depending on the rainfall, which in this tract is usually sufficient for the light sandy soil. Another drawback to the irrigation on this canal is that the bed has to be kept at a 2 feet higher level than it ordinarily would be because of the proximity of sub-soil water, and such conditions must unavoidably continue so long as the canal head cannot be taken off higher up the river. This is not possible, as the canal head is situated in another district, and compensation is not given for land taken up on these canals.

Paragraph 13.—The straightening of the numerous curves is a most desirable measure, but is attended with many difficulties, as I have noticed in the case of the Nizampur which was straightened in the course of the remodelling operations. The existing arrangements for irrigation are upset and lands that have been dependent on canal irrigation for years are

suddenly left dry and separated from the canal by lengths of disused channel. Another difficulty is that times have changed and people are not so ready as formerly to give up land free of compensation for improvements by which they themselves may not possibly benefit.

Mr. Herdon estimates that to put the canals in good order would cost at least nine lakhs of rupees. I will, however, deal with the financial aspects of the canals later.

Rough estimate of cost of these improvement.

Paragraph 15.—Colonel Grey all along scouted the idea that the canals could cause water-logging and produce *reh*. In his memorandum of 1891 he reiterated these views writing, "five months irrigation on a sandy sub-soil cannot cause water logging and sickness. Nor can it cause *reh*, and in fact I have seen none except in a few isolated patches, where irrigation is insufficient, and even there in quantity which is advantageous rather than otherwise, as may be seen on the wellands of Multan, Muzaffargarh, Dera Ismail Khan and Bahawalpur."

The Assistant Settlement Officer and I have already commented in the Zire, Ferozepore and Mamdot Assessment Reports on the alarming increase in *kallar* and large decrease in cultivation from this cause. There appear to be two sets of conditions which tend to produce *kallar*. In the first place, there are lands which lie comparatively high and are surrounded by copiously irrigated lowlying lands, such are the five Dhora villages of the Mamdot Jagir, that lie in the Muktsar Tehsil and some others along the bank of what may be termed the western branch of the Sukkar, such as Sheikh Shaman; in these last Mr. Francis at last Settlement (1891) noted that *shor* was present.

Secondly, there are the lowlying villages, such as the Sotarya villages in Mamdot and some villages near the navigation channel in Ferozepore Bet, in which the irrigation has been copious and which have at times, it seems, suffered from swamping of the crops by the combined effects of the canal irrigation and rain. In these two there has been some decrease in cultivation owing to *shor*, while such villages suffer badly from noxious weeds. Everywhere as may be seen from the Assessment Reports, it is noticeable that a high percentage of *nahri* land is accompanied by the presence of *shor*.

In many villages in the Muktsar Tehsil the great spread of *shor* is dated from 1908, a year of abnormal rainfall, or as the people put it, the year in which Fazilka was swamped. This would point to a lack of natural drainage and a spring level so high that the rainfall, coupled of course with a copious canal supply in such a year, could not be absorbed. The blocking of natural drainages has been largely caused by the Grey Canals which have in many cases cut straight across such channels as the Sukkar and the Sotar.

The Zamindars hold that copious irrigation is the remedy for *shor*. This may be true where a copious supply of water is accompanied by efficient drainage, but in most cases copious watering in the long run only increases the evil, though crops of a sort can be grown with plenty of water on land not too heavily impregnated with these salts.

There are two sorts of *kallar*, viz., the white and the black. The former makes itself obvious by whitening the lands and producing a puffy crumbling surface, while the latter gives the land a hard shining appearance. I am unable to say what constitutes the chemical difference between the two.

Paragraph 16.—Colonel Grey himself remarked on the rise in the water-table. The depth to water is given in the following table which gives the figures for the circles with most Grey Canal irrigation:—

Tract.	DEPTH IN FEET.			
	To water.		Of water.	
	Last Settlement.	Now.	Last Settlement.	Now.
Bet Zira	13	12	8	7
Ferozepore	14	13	5	6
Mamdot	10	7	3	5
Jalalabad	12	10	4	8
Mamdot Dhora	16	14	5	6

App. D. 8.

These figures are taken from the respective Assessment Reports. They reveal a very high level for sub-soil water and a rise since last Settlement, which, though in itself not very much, is serious in view of the already high level of the water. As a matter of fact, some wells are said in the hot weather to be brimful with water.

Paragraph 17.—Mr. Francis in his No. 148, dated 16th April 1895, gave it as his opinion that "Zira is somewhat over-canalised." The 16th paragraph of the above quoted letter gives an excellent *résumé* of the case against the canals. As far as regards Zira, Mr. Francis wrote—

- (1) "They do not want much canal water in Zira, except in dry years or for rice-cultivation."
- (2) "Those who had wells would have done better to stick to them, and if the canals brought water to the well lands against their wish, it is a pity for it lowers the standard of agriculture."

"There is not always time enough to till and clean canal lands after the water is off them, and they are apt to get foul and unworkable,
- (3) "The water does much damage to buildings, also to stored grain."
- (4) "Too much water, damp buildings, and wet grain are unwholesome."
- (5) "The canal fodder is innutritious food for cattle. They work badly on it, last badly and often fall victims to disease. The horses and ponies of the Zira Bet have almost been wiped out by disease in the last two years."
- (6) "Canal percolation brings up salts, but stopping the irrigation will not remedy this, rather the contrary."
- (7) "Debt and alienation are due to idleness, bad management and loss of cattle and much of the idleness and bad management are due to repeated fever."
- (8) "Much of the damage by uncontrolled water is due to the want of *pukka* heads to irrigators' own water-courses or to the very bad maintenance of these water-courses, but
- (9) "The main canals nevertheless ought to be provided with masonry regulators, if possible, near their heads, so that we may not be obliged to have a canal running when we know it is doing damage."
- (10) "If we cannot by these means get the water under control we must ask Government to allow the Extra Assistant Commissioner in charge to exempt involuntary irrigation at discretion, cost what it may."

As a result of this agitation the Daulatwah was closed for a year and the supply run down the Bacherewah reduced; steps were also taken to bring the water under better control. A very good summary of the results of canal irrigation in Zira is given by Mr. Middleton in paragraph 14 of the Zira Assessment Report.

Paragraph 18.—My conclusion is that in the purely riverain tract, which is subject to river floods the canals have had practically no effect except in a few isolated cases where their embankments may have prevented the spread of river flood. In the rest of the Bet I think, the spread of *kallar* and weeds with the consequent decline in cultivated area must be ascribed to the canals, though it must be remembered that but for the canals many hundreds, perhaps I should say many thousands, of acres which now bear crops would be lying waste. In the Rohi tract the canals have done nothing but good; the light soil does not become water-logged and soured by *kallar*, while to some extent the silt carried by the canals has improved the texture of the land. To my mind the great evil caused by the canals has been the decline in well irrigation. Of course as Colonel Grey insisted the ideal is for the canal irrigation to be supplementary to well irrigation, but the average inhabitant of the Bet, though an exception may be made in the case of some Arains, is too indolent to work wells, when he can get some sort of a crop with the aid of canal water.

Paragraph 33.—There has been much correspondence at various times on the subject of the management of these canals. In a supplement to the report of 1875, Col. Grey suggested that Government should take over the canals paying for the land and labour. He estimated that fair compensation would amount to 1½ lakhs. The proposal was, however, negatived.

Paragraph 34.—Recently the proposal has been again put forward and was dealt with by the Commissioner, Jullundur, in his No. 2182 to the address of Junior Secretary to the Financial Commissioners. As stated in that letter, there are many objections to Government taking over these canals. In the first place the step would be extremely unpopular with the irrigators who are after all the owners of the canals, though this fact is not always borne in mind. Secondly, from a perusal of the notes written by various Canal officers at different times, *e. g.*, (1) by Mr. Palmer in 1875; (2) by Mr. Jeffries in 1908 and (3) by Mr. Purves in 1912; it would seem very doubtful if the Irrigation Department would consent to take the canals over in view of the very large sums that would have to be spent to put the canals into technically proper order. Personally, I think, that if the canals were taken over it would be necessary to acquire them as the people would certainly demand compensation for land taken up for re-alignments and the like if the management was in the hands of a Government Department, and it would lead to endless confusion if some lengths belonged to Government and others to the Zamindars.

Paragraph 35.—It is very hard to form any estimate of what the compensation payable would amount to. I have had the cost of works compiled from the annual reports and the cash-book, but very much doubt the accuracy of the figures which do not agree with those given by Mr. Atkins in 1908. I give the figures for what they are worth in Statement VII. Mr. Atkins' figures are also given. Roughly, I should say, the amount of compensation payable would be between 25 and 30 lakhs of rupees.

As regards the compensation that would have to be paid for the land occupied by the canals, I have collected figures showing the areas occupied by the canals according to the latest records. The areas are—

					Acrea.
In Ludhiana District	...	..	...	...	104
Zira Tehsil	...	...	...	...	2,747
Moga	...	...	...	...	335
Ferozepore	...	...	...	...	2,521
Muktsar	...	...	...	...	1,926
Fazilka	...	...	...	...	1,087
Total	...	...	...	...	8,720

Putting a very low valuation on this area as *banjar* at the rate of Rs. 30 per acre the compensation would amount to Rs. 2,61,600. A consideration of these figures even after allowing for the fact that a large amount of the money expended has not been capital expenditure, shows clearly that the compensation which would have to be paid would be a prohibitive price to pay for a system of canals whose existence, at any rate in their present form, will come to an end if the projected new canal from the Sutlej is constructed. The Financial Commissioner wrote in 1908. "Mr. Wilson has here to note that it would cost an impossibly large sum to acquire these canals under the Punjab Minor Canals Act." In view of the above consideration, I consider that these suggestions that the Irrigation Department should take over the Grey Canal system is beyond the range of practical politics.

Paragraph 36.—Another suggestion that has been made is that the Irrigation Department should take over the Grey Canals as a running concern and administer them on behalf of the people who are the owners. Such departmental management would, I think, be highly unpopular, and there would be constant friction between the officials in charge of the canals and the Deputy Commissioner who would be called on to supply funds for improvements which the irrigation experts would inevitably consider not merely desirable but absolutely essential. Personally, I consider it highly doubtful whether, in view of the uncertain future of these canals, the Irrigation Department would be ready to take them over. I, therefore, consider that this scheme must be discarded.

Copy of a petition, dated 15th January 1917, from the Zamindars of certain villages of the Grey Canal tract through Karm Singh, brother of Santa Singh, Lambardar, village Khushal Singhwala, Tehsil and District Ferozepore, to the Superintending Engineer, Sirhind Canal Circle.

WE the following Zamindars of villages Khushal Singhwala, Gillanwala, Hastewala, Walur, Kakuwala, Sande Hashim, Asal, etc., who have affixed our thumb marks to the petition in vernacular most humbly and respectfully beg to submit as follows :—

1. That owing to an irregular and inopportune flow of water in the Mayawahi Inundation Canal our crops have been materially damaged for want of water for the last several years.
2. That it is an open secret that the rise or fall in the status of the Zamindars in particular mainly depends upon the nature and quantity of their crops.
3. That the said Mayawahi Canal, experience shows, is usually dry at the time of crops.
4. That the Sirhind Canal sends off her excess of water into the river for about 6 or 7 months every year, which may with advantage be availed of by supplying the same to us for watering our fields.
5. That in case of *Rohi* villages fields are watered by the Sirhind Canal, we therefore pray that the same concession be extended to our villages also and thus the wastage in the Sirhind Canal water may be utilised. It is needless to add that this step although equally beneficial to the Government shall mean a permanent boon upon humble servants.

For this act of kindness we shall ever pray for your long life and prosperity.

Signed by 39 villagers, (including Lala Jagan Nath, Honorary Magistrate, shareholder of Ferozepore) of 11 villages, namely, Khushal Singhwala, Sande Hashamwala, Gillanwala, Hastewala, Walur, Kakuwala, Asal, Gill, Kul Sujan Singhwala and Sujanwala.

Copy of a letter No. 270, dated 22nd November 1916, from Syed Sardar Ali Shah, E. A. C., Superintendent, Grey Canals, Ferozepore District, to H. W. Nicholson, Esquire, Executive Engineer, Project Division, Sirhind Canal.

In continuation of my No. 123, dated the 27th April 1916, forwarding you four sheets of contoured plans, I would point out that no new alignments have been marked on these, nor have the canals been remodelled in any way since the contoured plans were prepared.

The Grey Canals were dug 40 years ago with free labour and land was also given free. Colonel Grey, the designer, therefore took advantage of all natural depressions and the only new digging done was linking up these natural depressions. The six annas water-rate which was then charged for many years following, was never sufficient to carry out any silt clearances, and bar the absolutely necessary silt clearances of the *head* reaches, the canals and distributaries have never been treated to systematic silt clearance in their entire lengths since they were dug 40 years ago. They are thus choked with silt, have a very irregular bed, nothing but a succession of ridges and therefore are totally incapable of carrying the discharges sent with my No. 122, dated the 27th April 1916. These are only *nominal* head discharges. The channels being able to carry this discharge, is quite another matter. I would, therefore, particularly bring to your notice that when the share of water to the Grey Canals is allotted under the new scheme, the above remarks regarding the present condition of the channels may not be lost sight of.

I regret the state of the canals was not noted in my previous correspondence, but Captain Herdon, their regular Superintendent, who is on tour in this district recruiting and whom I spoke to about the new scheme, and has been in charge of the canals since 1901, impressed upon me the necessity of pointing out the deplorable state the canals are now in, and in any new scheme affecting them, this should be pointed out. I, therefore, do so now.

As an example, I send you Longitudinal and Cross Section of a channel which under conditions noted above, we consider to be in fair order. I also send a special report on the present condition and future management of the Grey Canals prepared by Mr. Currie, who has just carried out the Settlement of the District. This will explain everything to you in detail. As Mr. Currie's report is the only one in the office and is constantly being referred to, its return as early as convenient by registered post is requested.

App. D. 11.

**Wajab-ul-arz (Records of rights and obligations) for Grey Canals,
Ferozepore District.**

(TRANSLATION.)

As we the landowners of the village have proposed the construction of canals within our lands of our own free will and choice, accordingly we subscribe to the following conditions in the way of a *Wajab-ul-arz* and agree that they will always be binding upon us:—

**PART I.—Rights appertaining to the land covered by
the canals and to the Supervision of canals.**

1. We shall not claim any price or compensation from the Government for the land of our village taken up by the canal, its banks or spoil, and we shall not apply to the Government till the new settlement, for reduction of land revenue assessed on the land so taken up. If that land is exempt from the payment of land revenue, then no arrangements are needed; if it is under assessment, then we shall pay as usual the land revenue of that *khata* (portion) jointly, or this revenue shall be added on to the *khata*s (portions) of all share-holders proportionately, according either to ancient custom or to the number of ploughs, or to the *khewats* (a recognised unit of land) whichever system is in vogue in the village. If any land is taken up which belongs to some particular *khata* (land unit portion) or share-holder or tenant in possession, then we shall indemnify him by transferring the *shamlat deh* (village common land) of that *patti* (village sub-division), *thullah* (part of *patti*) or village with which it is connected and the land taken up by the canal shall be transferred to the *patti*, *thullah* or *shamlat deh* and shall be maintained in the same capacity in which the village common land was on transfer. At the time of the partition we shall divide up the land and the Government shall have no concern in the matter.

2. If in the course of the excavation of canal, any trees or standing crops are found in the canal bed, banks or spoil, we shall not sue the Government for the damages sustained. If on account of flooding, our crops or buildings are damaged, we shall put forward no claims, because small losses result in bigger gains. Moreover the work is ours and ours the losses and gains.

3. We shall have no right to bring under cultivation spoils, banks or the canal bed. We shall be responsible for the establishment of bench marks and the supply of labour to the Surveyors and also for their safeguard within our limits. We shall not damage the canal banks by traffic, bullocks or ploughshares.

4. We shall plant trees on the canal banks and shall water them from the canal. And these trees, reeds, *pilchhi*, etc., and other products of water, fish, water-nuts, etc., and grass that shall grow on the canal within our limits shall be our property. But if anything of the products mentioned above is ever required by the Canal Department for the maintenance and repair of canals at any time, we shall not refuse to deliver it.

PART II.—Excavation.

5. Whatever portion of the canal is allotted to our share by the Superintendent, Canals, for excavation in proportion to the area irrigated, shall be excavated by us with pleasure, and we shall carry out completely all the directions given by the Canal officers, as to depth, width and the distance at which spoil has to be deposited and other matters connected with the canal construction.

6. We shall do the usual annual clearances (proportionately) as for new excavation that is, we shall satisfactorily dig out that portion which falls to our share in proportion to the area irrigated.

7. In these ordinary clearances, we shall throw beyond canal banks any silt taken out and shall raise no objection if any land is taken up by this deposit of silt in addition to that previously covered by canal and spoil banks.

8. We shall construct or repair according to directions, embankments or spoil that come in our limits and shall not cut through them without permission. And in whose charge they are left, shall be responsible, i.e., we shall undertake to protect the banks and spoils situated within our respective limits as ordered. And in case of a breach, all of us benefitted by canal water, shall at once repair the breached bank and shall supply all material required for the purpose.

9. We shall supply proportionately all the tools and plant required for the canals and embankment.

10. If for the maintenance of the canal any new work is to be taken in hand, for instance, the construction of banks (*bund*) or new head on account of the demolition or washing away of the old, we shall be bound to execute it like ordinary clearance work and we shall be authorised to do it either by ourselves according to the amount allotted to our share or leave it to the Superintendent, Canals, to have it done and to realize

the outlay from us in proportion to the areas irrigated. If money is borrowed from the District Funds for the execution of this work (to avoid delay) then we shall contribute to the District Fund our share of it in proportion to the area irrigated.

11. Excavation of whatever kind shall be carried out according to the following method:—The excavation shall be allotted to the people of every village receiving canal water by volumes of earthwork and in proportion to the area irrigated and a time-limit shall be fixed during which they shall have to arrange for the completion of their portion of the work. In this period, no Canal Officer shall interfere with their arrangements. If the work be not executed within the time prescribed then the Superintendent of Canals, shall have the right to get the work executed by daily labour and to realize the cost thereof from the irrigators concerned proportionately.

12. As the Canal Department has been established for running these canals for us we agree to maintain the establishment by contributing to the charges thereof at rates fixed per unit of area irrigated in a common meeting.

PART III.—Administration.

13. We shall construct bridges or make other arrangements for communication wherever a village path happens to cross a canal. We shall not abandon the existing paths and make new ones. We shall have no claims on the Government (for the cost of such constructions) of course the highways shall have to be arranged for by the Government (for bridges, etc.)

14. We shall never endeavour to put a *bund* in the canal. However, the Superintendent of Canals shall have full powers in the matter. We shall not irrigate except through *paeca* outlets. We shall set up *jhal'ar*, *jhatta* or *dhinkli* (plant for lift irrigation) outside the canal limits and shall dig water-courses according to instructions.

15. Whenever the Government refuses to give water or stops irrigation, we shall not claim any remuneration or compensation for damage sustained, that is, we depend for our water on the free choice of Government.

16. We shall not stop the irrigators of a particular village or an individual irrigator whether of our village or of a neighbouring one, whenever they may require to bring water to their lands through the lands of one or more land-holders, nor shall we quarrel over the lands or crops that may thus be damaged, for the chances are the same for every one of us, as anyone may sometimes require to carry water for his lands through the lands of another land-holder.

17. If more than one irrigator happen to have a water-course in common we shall by mutual agreement arrange for the irrigation of our respective fields by turns. Whoever contravenes these provisions, shall be liable to fine and compensation for the damage caused. A list of this arrangement of turns shall be kept in the Superintendent's Office. Any irrigator who obstructs a water-course (minor) to head up water shall have to obtain the consent of all other irrigator concerned. No irrigators shall be authorised to meddle with water without the written consent of others.

18. If any irrigator resigns his concern with the canal, he shall forfeit all claims to his share of the contribution of expenditure and to all his previous rights as they will be considered null. If the remaining set of irrigators refuse to buy his share, any one of them shall be entitled to buy it. If the lands of the irrigator who has resigned his concern, get canal water, he shall be liable for payment of water-rates according to the quality of the land and crop grown. This sum shall go to the common fund for expenditure.

19. We shall obey implicitly whatever orders be issued by the Government from time to time.

20. Any person who contravenes the provisions of the above agreement or stands in their way or acts against the various orders and instructions regarding the canals, shall be liable to punishment by the Government.

21. We shall continue to pay at 4 pies per acre of area irrigated for remuneration of the services of the *Mirab*, who shall be appointed, with our consent for the distribution of water. Similarly we shall pay the *Patwari* as remuneration for land measurement, at two pies per acre of the area irrigated, or if the rates change, we will with the rest of the irrigators pay according to changed rates. We shall use water as directed by the Superintendent through the *Mirab*.

22. We agree that we have thoroughly understood the contents of this agreement which has been recorded by us as *Hajab-ul-arz* (Records of rights and obligations). And all of us undertake to act according to its provisions and if anyone of us contravenes its provisions and for that the canal sustains any loss, the Superintendent of Canals shall have the right to bring the liability home to him to behalf of all us.

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